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MINERAL RESOURCES OF MINAS GERAES (BRAZIL)

A. F. CALVERT

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MINERAL RESOURCES OF MINAS GERAES (BRAZIL)

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(BRAZIL)

BY

ALBERT F. CALVERT, F.C.S., ETC.,

Knight Grand Cross of The Royal Order of Isabel the Catholic, Knight Grand Cross of The Royal Order of Alfonso XII., etc.

AUTHOR OF

Mineral Resources of Western Australia, South-West Africa, Nigeria and its Tinfields, The German African Empire, Salt in Cheshire, My Fourth Tour in Western Australia, The Exploration of Australia, Editor The Spanish Series, etc.

UNIV. OF CALIFORNIA

LONDON:

E. & F. N. SPON, LIMITED, 57, HAYMARKET.

NEW YORK:

SPON & CHAMBERLAIN, 123, LIBERTY STREET.

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PREFACE

EVERY writer who has made a study of the mineral resources of Brazil has been struck by the amazing anomaly that proportionately as the incalculable extent and richness of those resources has become better known, the mining industry of the country has diminished. Many reasons have been advanced to explain the enigma that the facts present. The liberation of the slave-workers, bad legislation and exorbitant taxation, lack of railway communication, political unrest and financial instability, and the incompetence and dishonesty that have attended the exploitation of the mines and the management of the companies that have been formed to work them, are among the numerous disabilities from which the industry has suffered in the past; but while these drawbacks are being steadily removed, the disfavour, into which mining enterprise in the Republic has fallen, remains. The Brazilians themselves, apparently indifferent to the enormous national asset which these minerals represent, have devoted their activities to agricultural advancement, and it would almost seem that these people, with a score of potential gold-fields at their very doors, are immune from that "gold fever" which has rendered possible the recent stupendous progress that has been made by a host of other countries less rich in minerals than their own.

The diamond industry of Brazil is a dwindling enterprise in the hands of individual prospectors and ill-equipped bands of miners, although for a century and a half which succeeded the discovery of the first brilliant in Diamantina, Brazil's output of diamonds exceeded that of any other country. Before the development of the "banket reefs" of the Rand and the "deep levels"

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of Australia, Brazil held the world record for gold production. One of her mines has yielded gold to the value of over eleven and a quarter millions since it was acquired by an English Company, another nearly two and a quarter millions, and a third over a million and a half. Still another property made possible the distribution of over 100 per cent. dividends for three successive years, and in 1868 produced two and a half tons of gold. Professor Soetbeer has estimated that the total gold production up to 1875 was £144,668,475, exclusive of the enormous quantities which were smuggled out of the country, paying no taxes and leaving behind no record of its recovery or removal. There is not an auriferous deposit in the country that has been exhausted or anything like it, yet scores of mines have been abandoned, and the industry at the moment is practically moribund. In the extent and purity of her ferruginous ores, Brazil possesses more important iron reserves than any other country, yet very few of the deposits are being systematically developed, and the manufacture of iron is limited to the operations of two smelters. Platinum, manganese, mica, and almost every variety of mineral and of coloured stones have been located in the State of Minas Geraes alone, but only the most desultory endeavour has been made to work them and bring them to market.

All the testimony of geologists and metallurgists of world-wide repute is agreed upon the extent, variety and richness of Brazil's practically inexhaustible mineral treasure, and superlatives have been lavishly employed to describe the individual mines and districts and deposits. Monsieur Henri Gorceix, the eminent French scientist, described the State of Minas Geraes as "a heart of gold in a breast of iron." Signor Alcides Medrado says that "experts who have visited Minas Geraes declare that it is one of the richest gold-fields on earth," and Monlevade, the French engineer, speaking of the iron reserves, affirms that a

single one of the gigantic iron ore deposits of Minas Geraes contains more iron than all the mountains of Europe put together. Mr. W. H. Herdsman has described the Pico d'Itabira as "a real mountain of iron," and Signor Arrajado Lisbao asserts that "when the manufacture of iron by electricity becomes an economic reality, no country in the world will offer more advantageous conditions for the development of the industry, not only because of the abundance and superior quality of the ores, but also because of the available sources of hydraulic power." This authoritative opinion is confirmed by that of Mr. H. Kilburn Scott, who writes: "I have examined the Lake Superior deposits, as well as extensive beds of ore in other places, and I am decidedly of opinion that the Brazilian deposits exceed, in a very appreciable degree, any I know, both as regards the quantity and quality of the ores, as well as in the facility of mining." Mr. E. C. Harder, the well-known mining engineer, gives the average result of 89 analyses of the Minas Geraes hematite ores at over 69 per cent. of iron, and adds that "in few places in the world has iron ore been found in marketable quantities which even approaches this in grade." Mr. William Selkirk and Dr. de Campos, of the Brazilian Geological Service, are no less emphatic in their conclusions. "The quality of the ore," writes the former, "is, without exception, the finest I have ever seen in the whole of my experience, and finer than any I have ever heard of," and the latter declares that "as regards the percentage of metallic iron, and particularly the purity of the ore, we believe it to be unrivalled in the world."

Referring to the possible content of iron ore in the region of Minas Geraes, Dr. Derby states that any attempts to estimate it must be extremely fallacious. For the purposes of the International Geological Congress (Stockholm, 1910) he placed the total tonnage at two

billion tons. Professor Gorceix estimated it at five billion tons, but considered he would not be exaggerating if he doubled that estimate. Messrs. Leith & Harder state that " the tonnage is probably not far short of the total reserve of available ores in the Lake Superior region to-day" (1911). It is possible that Gorceix's revised estimate of a probable ten billion tons will be nearest to the actual output, for the Government mining engineers calculate that the 52 outcrops they have surveyed contain not less than twelve billion tons of ore of the highest possible grade.

The fact that, in the face of such enthusiastic and unanimous scientific testimony, these gold mines have been abandoned, and these iron deposits have been ignored, only shows to Monsieur Touzeau that the mining history of Brazil forms no exception to the rule of mining that repeats itself in every country. The first stage is marked by the rush to participate in the scramble for the rich alluvials. Then follows the period of ill-advised expenditure of capital and the flotation of worthless and unproved properties, and the consequent interval of discredit, when sound and unsound ventures suffer alike, and this is terminated by the process of weeding out the bad concerns and the prosecution of the good ones on legitimate lines. Brazilian mining reached the discredited stage and stopped.

But in the meantime the obstacles that frustrated the early development of the industry are being overcome or removed. The Central of Brazil Railway from Rio de Janeiro, the only system at present serving the mineral zone, is duplicating the track and adapting the road for ore-carrying purposes. The Victoria to Minas line has already been completed to Baguary, and a powerful group of English and French financiers are arranging to connect up the iron district with this system, and to spend a considerable further sum of money on

improving the loading facilities at Port Victoria. A concession has already been granted for yet another railway from the iron district to a deep-water port, south of Port Victoria, which will bring the deposits a hundred miles nearer to the coast, but this scheme will not be carried out until the war is over. But with these improved means of transport, with the introduction of modern plant and machinery, and new methods of treating the ores, we have a combination of facilities that will enable Brazil to enter upon her last period and complete the history of her mining industry with every prospect of success. She may never recover her proud position as the greatest diamond-producing country; it may be that her period as the world's record gold producer is also irrevocably past; the tales of the streams "running over sands of gold" are not likely to be repeated; but she will, I am convinced, only exchange the reputation of her former glories for a record sounder and more enduring.

Brazil has suffered all too long from the explicable but entirely undeserved neglect of the practical, the scientific and the capitalist branches of the mining fraternity. Her interests, to employ a phrase understood in the City, got into wrong hands, and the venue became unfashionable. When Lake Superior was recognised as a fashionable field for investment, the necessary capital for the exploitation of her iron ores was quickly forthcoming; when Coolgardie acquired favour on the strength of startling but unproved discoveries, a railway was immediately thrust into the West Australian desert to convey electrical plant and modern appliances to the scene of mining operations; fashion unlocked the coin required to mint the auriferous deep levels of Australia and the Rand; and it more recently built trunk and branch lines for the idle purpose of burying millions of pounds of investors' money in the illusory tin-fields of

Northern Nigeria. Such money as was lost in Brazilian exploration in the past has purchased proof beyond dispute of the richness of her gold regions, the phenomenal extent and purity of her iron ore deposits, and the existence of her abundance of manganese and other minerals. Practical men have mastered the mystery of her jacutinga formation, and modern machinery is capable of solving the simple geological and metallurgical problems that her exploitation presents. All that is now required is to direct the attention of the public to this land of promise, and to invite them to examine the credentials she has furnished of her mineral plenitude and satisfy themselves as to the soundness of her mining future. The minerals are there, the diamonds, and the gold, and the iron, and it is with the object of describing, explaining and demonstrating the potentialities of these districts and deposits that I have compiled this modest book. I have gone for my facts to unimpeachable sources of information. I have searched official records and read all the available literature that has been published on the subject in English, French and Portuguese, and I have consulted a number of geologists and mining men who have investigated the subject in the Brazilian mineral zone.

Some idea of the sympathy and practical assistance I have received in my work, and of the invariable courtesy that has been extended to me by everybody connected with the country whom I have approached in connection with it, may be gathered from the long list of persons to whom I am glad to tender my cordial thanks. To Mr. C. F. W. Kup, of the St. John del Rey Mining Company, Ltd., Mr. S. H. Wells, of the Ouro Preto Gold Mines of Brazil, Ltd., Mr. James Miller, of the Sao Bento Gold Mines, and Mr. Stephen Rowe, of the Parral Mining Corporation, I am indebted for photographs and much information

concerning the gold mines and auriferous areas, while further valuable data on these subjects has been supplied to me by Mr. Hugh Pearson and Mr. J. H. Goodchild. In connection with the ferruginous districts and the iron ore deposits I am under special obligation to Mr. C. F. Levick, of the Itabira Iron Ore Syndicate, to Mr. William Jones, Mr. William Selkirk, Mr. A. H. Mannheim, and Mr. Herbert Kilburn Scott. Mr. William Jones reported on these iron districts on behalf of certain persons in the United States, including Mr. John Hays Hammond, who are interested in their future, and the photographs taken by him are among the best I am able to reproduce. Mr. Mannheim was one of the first engineers to report on Brazilian iron properties, a work he undertook at the instigation of Mr. P. Murly Gotto, of Rio de Janeiro, and, with the assistance of Mr. W. T. Atherton, a practical Australian mining man, he has done much excellent work in connection with the investigation and development of these deposits. Mr. Mannheim very kindly placed his report and plans at my disposal, and so made me free of a great store of valuable information. Mr. Kilburn Scott, who is so well known as an authority on the gold, iron, manganese, and mica deposits of the country, has allowed me to draw upon his many and exhaustive papers on these subjects and to use a number of his photographs.

To all these generous helpers and *collaborateurs* I am pleased to acknowledge my indebtedness, and I take this opportunity to express the hope that they will approve, both in the matter of the text and of the illustrations, the manner in which I have availed myself of their generous assistance.

ALBERT F. CALVERT.

"Royston,"
Eton Avenue,
N.W.

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UNIV. OF CALIFORNIA

MINERAL RESOURCES OF MINAS GERAES

(BRAZIL)

ALTHOUGH it has been proved beyond all shadow of doubt that Brazil possesses an incalculable wealth of mineral treasure of every description, distributed in the greatest abundance in practically all the twenty-two politico-geographical divisions of her immense territory of nearly three and a quarter million square miles; although she has held the world-record for gold production, and boasts of iron deposits which exceed all others, both as regards the quantity and quality of the ores as well as the facility of working them; the Brazilian mining industry at the present moment is in an almost moribund condition. The most striking of many anomalies presented by the industry is its decadence in the face of the unimpeachable evidence as to the enormous area of gold-bearing lands, and the magnitude and phenomenal richness of her iron deposits, given by scientists and geologists of world-wide repute. Humboldt, the members of the Agassiz Expedition, P. Calogeras, Orville Derby, Gorceix, and others have all borne testimony to this effect. Gold has been found, without any recent systematic prospecting or Government encouragement, in fully two-thirds of the Federated States; the St. John del Rey Mining Company and the Ouro Preto Gold Mines of Brazil have produced gold, up to 1914, to the value of £11,293,067 and

£2,156,480 respectively; yet these two companies are the only regularly-producing gold undertakings in the country at this moment.

The cause of this curious anomaly was the subject of an article by Carlos S. Rutlidge, which appeared in *The Times* in April of last year. Before the development of the Rand "banket reefs" and the Australian "deep levels," and the raising of gold-mining to the rank of an exact science, Brazil had won world-fame as an El Dorado, and to-day, with a score of potential gold-fields at their very doors, Brazilians exhibit the unprecedented spectacle of a nation of some 20 million souls apparently immune to that "gold fever" which has made possible the recent stupendous progress that has taken place in California, the Transvaal, Victoria, New South Wales, Western Australia, and a host of other places. Brazil is richer in minerals than any one of these countries; the unexhausted and practically inexhaustible condition of her old mines guarantee the wealth of her virgin areas; but no attempt has been made, when the alluvial has been bottomed, to follow up and locate the mother lode with a view to that systematic development which has been undertaken with striking success in so many other parts of the globe.

INCOMPREHENSIBLE NEGLECT EXPLAINED.

The Times explains this incomprehensible neglect as being due, in the main, to bad legislation, coupled with the fact that until the recent liberation of the slaves—then constituting the great bulk of the population and at the same time the only workers—there were few to whom the adventurous life of a gold-seeker appealed. Since that time developments have been more along agricultural lines, in addition to which events of political and economic importance have so crowded themselves

upon one another that the greater number of the Brazilian people have not yet been able to realise the importance of this undeveloped national asset. In the early part of last century, when English capital began to flow into Brazil, great difficulties were encountered in the transport of machinery and stores over long distances in a country which had no railways and only the worst and roughest of roads, and the industry was inevitably retarded by the disastrous fluctuations in the exchange value of the *milreis*. Lack of labour and a scarcity of timber in many places also militated against mining development, and the nature of these disabilities will be treated in more detail in the present survey.

A concise and convincing explanation of the situation is given in Mr. E. M. Touzeau's paper on "Gold Mining in Brazil," in which he says: "The history of gold mining seemingly repeats itself in each country, nay, in each field, with such a fidelity to detail that the mistakes made have borne a general family resemblance, and that of Brazil forms no exception to the rule. A period when gold is found plentifully at surface or in shallow workings is followed by the lavish and often ill-advised expenditure of capital. To this succeeds a stage of discredit when sound concerns suffer with unsound, only to be terminated by a gradual weeding out of the bad, and a prosecution of the good ventures on legitimate lines. Brazil reached the discredited stage and stopped. Her history, therefore, lacks the completeness afforded by that of later gold-producing countries, which have each found their check to have been a salutary lesson, leaving them the stronger for its teaching. With the knowledge gained in more recent fields, the advantages of modern machinery, and the better means of transport now afforded, Brazil may yet hope to give a good account of herself, and emerge from her present obscurity. During the years which have elapsed since English mining enterprises

almost ceased in Brazil, the methods and means of extracting and treating ores have advanced sufficiently to make the poor and unworkable property of that date a workable and payable one to-day."

FIRST DISCOVERY OF GOLD.

The first Portuguese adventurers in Brazil had no sooner secured a footing for themselves on the coast than they commenced to penetrate the interior where, in the course of time, their activities were to be rewarded by the discovery of rich deposits of gold and other metals. These pioneers, who were known as Paulists, or *Paulistas*, from the name of the village of Sao Paulo, were raiding the Indian territory on slave hunting expeditions when they heard rumours of the existence of precious stones in the almost inaccessible regions of the mountainous hinterland, and they were on a quest for men and not for minerals when they reached the banks of the Rio Doce, towards the middle of the second half of the sixteenth century, and secured tangible indications of the auriferous resources of the colony. During the next hundred years the ardour of the explorers was cooled by the practically insuperable obstacles that the country presented, and it was not until 1693 that Antonio Rodriguez Arzao, a native of Taubaté, procured actual specimens of Brazilian gold. Accompanied by a party of fifty men, he crossed the *sertoes* (mountainous regions covered with thick forests) of the Rio Doce to the district of Caethé, and there, guided by an Indian, he was able to collect several nuggets. He returned to Taubaté for the purpose of organising a further expedition, but succumbed to the rigours of his laborious efforts, leaving the diary of his investigations to his brother-in-law, Bartholomew Bueno. This man, a ruined gambler anxious to rehabilitate his wasted fortunes, recruited a party of relatives and friends in 1694, and succeeded in

reaching the Serra d'Itaverava, eight leagues from the spot which was to be occupied later by the City of Ouro Preto. Although unequipped with iron tools and suitable washing appliances, Bueno contrived to secure a certain quantity of precious metal, which he exchanged for a carbine with a man employed by another party who were exploring in the district. This individual immediately deserted his party and retraced his steps to Sao Paulo to proclaim his discovery. But at Taubaté he confided the story of his good fortune to a friend who, despoiling him of his gold, fled to Rio de Janeiro, where the Governor, as a recognition of the discovery he had not made, appointed him *Capitao-Mor* (Captain-Major) of the town of Taubaté.

THE CITY OF OURO PRETO FOUNDED.

The acceptance of the fact of the existence of auriferous deposits sufficed to revive the adventurous spirits of the Paulists; a current of emigration towards the *sertoes* set in, and the discoveries of gold outcrops became more frequent. The Paulists, Antonio Dias, Thomas Lope de Camargos, Francisco Bueno da Silva, and the Padre Joas de Faria Fialho, were the first who discovered gold in the district of Ouro Preto in 1699, 1700 and 1701. The dark colour of the metal gave to the mountains the name of Serra d'Ouro Preto (the Mountains of Black Gold), and when a town arose at the foot of the Serra, it was given the same name. The richness of the ores attracted a horde of adventurers to the district, and Ouro Preto rapidly became the centre of a vast territory which was subsequently called Minas Geraes (General Mines) from the wealth and variety of the minerals located in the province. This region was first placed under the dependence of the Capitainerie Générale of Rio de Janeiro, but it was united in 1709 to

the territory of Sao Paulo to form the Capitainerie Générale of Sao Paulo and Minas, with the town of Sao Paulo as the capital. The first Governor of the new province instituted a system of taxation upon the mineral produce and conferred the rank of town upon Ouro Preto, which became Villa Rica de Ouro Preto (Rich City of Black Gold) on July 8th, 1711.

In order to exercise a more strict control over the constantly-increasing population of the new territory, and to repress in a more efficacious manner the spirit of rebellion among the miners, upon whom the heavy tax of the *quinto* (20 per cent. of the value of the gold won) weighed heavily, the subordinate Capitainerie of Minas Geraes was raised on December 2nd, 1720, to the independent state of Capitainerie Générale with Villa Rica as capital. In the same year gold was discovered at Itabira de Matto Dentro. Upon the declaration of the independence of Brazil in 1822, the capital was raised to the rank of city under the title of Imperial Cidade de Ouro Preto.

" The position of the capital of Minas Geraes," writes Francis de Castelnau in his *Expedition dans les parties centrales de l'Amerique du Sud* (Paris, 1850), " has been entirely decided by the wealth of the territory on which it is built, for from every other point of view, it would not be possible to have chosen a worse place. On all sides it is surrounded by high mountains, in the midst of which is distinguished afar Itacolumy, with its summit bent in the form of a blunt horn." Everywhere, in the town itself, are seen vestiges of ancient works, mountains overthrown, their sides torn and scarred by the attacks of man ; immense reservoirs with their thick walls composed of huge blocks of stone, cemented by earth, hardened by time—vast receptacles in which the auriferous

waters deposited their precious mud to be recovered in the course of ages for the sake of the precious metal contained therein.

FURTHER DISCOVERIES OF GOLD AND DIAMONDS.

Whilst Ouro Preto was being founded, many parties of explorers were pursuing their researches in other directions. Auriferous ores were discovered in the neighbouring State of Bahia, in the States of Goyaz and Matto Grosso to the east, in the States of Sao Paulo and Rio Grande do Sul in the south, and, in the north, in Maranhao. A party led by Colonel Salvador Fernandas Furtado, while exploring a tributary of the Rio Carmo, came to the river itself. This discovery led to the formation of an important centre, which received the name of Villa do Carmo in 1711, and, by Royal Charter of April 23rd, 1745, was made a city, with the name of Marianna, in honour of Queen Marianna of Austria, the wife of Don Joao V.

Small white crystals of irregular shape and no known value were next found in Minas Geraes, and collected as curiosities. It was not until the early part of the eighteenth century that these crystals were ascertained to be diamonds of the purest water, and Brazil achieved fame as a producer of the most valuable of precious stones. In more recent times a wide variety of gems including beryls, topazes, garnets, rubies, agates, amethysts, sapphires, tourmalines, and the beautiful aquamarines—which, in some specimens, are indistinguishable from fine emeralds—have been discovered in many parts of the country.

THE EARLY PRODUCTION OF MINAS GERAES.

Senhor Alcides Medrado, in his *Historical Sketch of Gold Mining in Minas Geraes*, says that if we consider the

proportion of the population attracted to the workings, no other argument is needed to demonstrate the wealth of the superficial gold deposits of that territory. In the writings of Antonil, published in 1711, we find the most valuable record of the first decade of the State's existence. At that period the brooks of Ouro Preto, Carmo and Bento Rodriguez were washed, and the amount of precious metal won is said to have actually justified the hyperbole of Claudio Manoel who described the streams as "running over sands of gold." We read that in these days no river was considered worth working unless a panful of sand gave ¼ oz. (Portuguese) of gold, valued at $3·50, while nuggets were common. The architectural achievements, the stately houses and churches yet remaining, tell of the luxury and splendour of these bygone times.

The seemingly extravagant statements made about the early production on the Rio das Velhas rest on no less an authority than that of the grave Xavier do Veiga, Director of the State Archives, a man noted for the severity and high degree of accuracy with which he examined all the figures passing through his hands. According to Do Veiga, between 1700 and 1713, the annual tax, excluding contraband, amounted to $197,500. This shows a production of over $975,000. Between 1715 and 1725, the annual tax had risen to $225,000, showing a production of $1,170,000 per annum. For the decade 1725-1735 there are no figures available owing to the removal of the books to Rio de Janeiro, but the output, judging from that of the preceding and succeeding periods, could not have been less than $1,400,000. From 1735 to 1751 the annual output reached $1,550,000, and from 1751 to 1777, $1,785,000. From these official figures it is seen that in less than 70 years the tax realised $40,000,000 on a production of gold to the value of over $220,000,000.

It is on record in the official figures for the period that the total amount of gold received by the Government on account of this tax was 7,131 *arrobas* or nearly 107 tons, equal to about £13,000,000 sterling (*arroba*=15 kilos). The epoch of greatest prosperity was between 1751 and 1781, when the tax amounted to 100 *arrobas*, or 1,500 kilos of gold per year.

RICH MINES AND BAD MANAGEMENT.

"The lack of intelligent exploitation of the properties," writes Senhor Medrado, "discredited without reason many rich deposits. A brief inspection of the auriferous belt will satisfy any competent engineer that scarcely one of the thousands of deposits then worked should have been abandoned. In Minas Geraes, as in the other gold-fields, the alluvial gold has been in great part removed, but there still remain the huge mountain veins absolutely untouched. . . . It is possible and more than possible that a new era is dawning for this ancient industry. Obstacles in the direction of transport and labour are gradually being removed, and the modern spirit of association bids fair to cope with difficulties too great for the old workers. Experts who have visited Ouro Preto declare that it is one of the richest gold-fields on earth. Not one mine here existing is yet worked out or near it."

Gold is found almost throughout the whole series of rocks in the gold-zone of Minas Geraes, but the bulk of that obtained by mining has been derived either from the quartz or jacutinga formations—the latter being a formation peculiar to Brazil. At Morro de Santa Anna, Rossa Grande, Pari, Antonia Pereira, and at many other points, operations were conducted either by English or Brazilian companies, but in most cases under

conditions which must have proved fatal to the success of almost any property, and entirely merited the judgment passed upon them by the *Mining Journal* in 1887: "The Brazilian mines contain plenty of gold, but there are no mines in the world which have been so badly managed."

Sir Richard Burton tells us that the Brazilian miner was "ever careless about timbering and walling; he little regarded lighting or ventilation; the Davy and the Geordie were equally unknown to him; he ignored pumping on a large scale, and thus, when his mine became watered, he was compelled to quit it."

In another passage in his *Explorations of the Highlands of the Brazil* (1869), relating to the failure of the Cata Branca Mine, Burton says that it resulted from two causes. "Firstly, there was an utter absence of economy (the first manager received a house, all civilised luxuries, and a salary of £3,000 per annum), and as Mr. Moshesh justly observes, with peculiar applicability to Minas, even gold may be bought too dear. Secondly, the mine was badly worked." Sir Richard is severe in his comments upon the unteachability of the Cornish miners who, "since the days of Howel or Houel, King of small Brittany, have been heaven-born miners with the airs of omniscience," and adds: "We shall trace these same two evils, reckless expenditure and want of exact knowledge, in the history of many other mining adventures. Hence it is that in this land of boundless mineral wealth, so many companies have come to grief, and so many a mine has been, to use the technical word, 'knocked.'"

GROSSEST MISMANAGEMENT AT HOME AND ABROAD.

Having thus disposed of the Brazilian miner and his Cornish successor, Burton denounces in vigorous terms the bad faith displayed by Englishmen in their dealings

in Brazilian mining matters. "It is said," he writes, "that the Englishman going to India, left his conscience at the Cape, and forgot to take it up on his return. I know not where Europeans deposit these troublesome articles when bound for the Brazil, or whether they care to recover them when *en route* homewards. It is, however, a melancholy truth that, in this country, honesty seems to be the smallest item of the adventurer's stock-in-trade. In the mines, as in the railways of the Brazil, the fault, the cause of failure, lies, I repeat, not with the Brazilians, but at our door. There has been the grossest mismanagement both at home and abroad. Private interests have been preferred to public; in certain notorious cases a system of plunder has been organised; impossible schemes have been floated through the market; the merest speculators have waxed rich; economy has been wholly neglected, and money has been buried as though it were expected to grow. The most lamentable result is the false conviction in Europe that the seed of capital cannot be sown profitably in the Brazil, when there is no country where, properly husbanded, it would be a better crop."

The early Portuguese settler and his Brazilian descendants were wonderfully successful as prospectors for gold, but their mining knowledge was very limited; and in every instance their works were abandoned when water was reached. At Ouro Preto innumerable small galleries were driven into the mountain side, and small shafts sunk, from which immense quantities of mineral were extracted, although a large percentage of its gold content was lost. For miles in an easterly direction the mountains are honeycombed by these shallow workings, and at Morro de Santa Anna, 5,000 miners worked their separate claims in a similar manner until the property passed into the hands of the Don Pedro North d'el Rey Mining Company, Ltd.

EARLY METHODS OF WORKING THE GOLD.

In the course of a report made by André P. Griffiths and E. A. Mannheim upon the Sao Vicente estates, situated about midway between Ouro Preto and the St. John del Rey Company's property, we read :—

" These gold-bearing schists have been worked on an extensive scale from a remote period, and the old workings, in the shape of long open cuts, are visible for many miles along a line running almost from Ouro Preto to close on Morro Velho, a distance of 30 to 35 miles.

" The method of working these gold-bearing schists consisted in bringing water in ditches from any point suitable, generally a distance of 10 to 12 miles, to the highest point of the various hills to be worked. This water was allowed to fall along the gold-bearing formation, and to wash into ground gutters or sluices all the decomposed rock and gold. These sluices gradually filled with the richer portions of the ground, and finally yielded the gold in dust and small nuggets. These workings, although following the face of the hills for continuous distances of as much as half a mile, and heights of 300 or 400 ft., are really alluvial workings. Apparently the work ceased as soon as the harder formation was reached. Many million cubic yards of ground must have been washed by this method over a period of many years. No record seems to exist as to the date of these exploitations, and the most that can be said in our present knowledge is that they must have been carried on centuries ago.

" These ancient workings cut through the hills known as ' Engenho da Cima,' ' Morro das Almas,' and ' Passo Tempo.' On the latter, however, on its eastern slope, very extensive workings exist, which though probably carried out on or about the same period, differ in character. They consist of open cuts followed by

inclined shafts and underground excavations. These were made on a belt of schists containing numerous veins of quartz, which appear to have been the chief source of the gold. In recent years, about the middle of the last century, these ancient workings induced Brazilians and later English capitalists to try and re-open or follow on these. In 1860 a Brazilian Company began sinking an inclined shaft at the bottom of the open cut on Engenho da Cima, on the hard gold-bearing formation. This inclined shaft is said to have been carried down about 700 or 800 ft. on the incline, and a considerable amount of work was done underground. Stamps were erected and crushings were made. I could not find any records giving the number of tons crushed or the yield, but from an old letter book found at Sao Vicente it would appear that the mine was worked for several years, and that the lode was 24 ft. wide."

ANCIENT WORKINGS AT SAO VICENTE.

Another account of the ancient workings on the Sao Vicente properties belonging to The Parral Mining Corporation, Ltd., is given in a report by another engineer, who writes :—

" The whole of the line of strike crossing the estate shows enormous evidences of the former workings ; this line is in extent about 4 miles. These great workings were all carried on in the seventeenth, eighteenth and early part of the nineteenth centuries by the original Portuguese and Brazilian colonists and pioneers. Whole valleys have been washed out, and vast and awe-inspiring cuts through the hills remain to show how truly great were the operations of these early days ; all this work was done in the decomposed outcroppings, and in nearly all cases ceased when water line or hard rock was reached. In two principal localities, mining in the rock was resorted to and carried on by private owners in a more or less

vigorous manner; these places are named respectively Mina Grande and Mina Morro das Almas. The private owners, after some time, handicapped by difficulties in the shape of want of machinery, explosives and immense transport distances, became disheartened, and from the year 1876 no work of any kind or even pretence at same was attempted till my advent in February, 1906. Traditions abound in regard to this place, and also some records to be seen in Ouro Preto, and other old records. From all of these it is easy to extract the fact that very large quantities of gold were extracted during all the early operations in the softer formation. Considerable amounts were also won from the rock operations, though it is easy to trace and assume the difficulties which had to be dealt with, such as crude tools and machinery, indifferent modes of stamping and treatment, &c.

"From old records, and from information extracted from old men who worked in the mines, I have deduced that the mines were approximately at about the depth of 200 ft., or thereabouts, when work was stopped. No definite plans of these underground workings exist, but some evidence is available that they were extensive: this refers more especially to the Mina Grande, which was the principal one. It is reported, and very considerable credence may be given to this, that at the bottom of the mine the workings were in a very large body of rich ore, 6 metres or more in thickness—one person gives the actual width as 24 ft.; from the smaller reefs outcropping and visible in this vicinity, and all trending in the direction of the old mine, one may assume considerable belief in this. It is here necessary to add that this old mine is entirely and effectually closed at its mouth, this being brought about by caving and a heavy land fall; the other mine at Morro das Almas is still open. There are many minor holes in various situations open along the strike. Two principal ones may be mentioned

as giving evidence of reefs: 'Esgoto' in vicinity of Mina Grande, where are three quartz bodies, 4 ft., 2 ft., and 1 ft. 6 ins. respectively, giving on assay values averaging 6 to 10 dwts.; 'Cata Seca,' some quarter mile from Mina Grande, quartz body 2 ft. 6 ins., giving similar assays. In both of these places some work has been done to expose the reefs, and at the latter quite a good few tons of stone are at surface. Next in point of attraction to these localities comes a large hill, 'Passo Tempo,' at the extreme other end of strike on property. The crown of this hill has been most extensively worked by original diggers, and as the trend of bodies is parallel with the slope of the hill, any payable reefs cut here by tunnelling would be mined in a most inexpensive way. Furthermore, in the actual close vicinity of this, power and timber are available, making it a quite independent unit, and one likely to show very early results and most certainly low working costs."

DIFFICULTIES OF ESTIMATING GOLD RETURNS.

The necessary data for arriving at a computation of the total value of the annual mineral production of the Republic is not available, and, owing to the prevalence of contraband traffic, the figures that may be gathered from the returns are not complete. But from such incomplete and heteromerous returns as are available, it would appear that the annual export from Brazil of all raw metals amounts to about only one million sterling, of which gold accounts are not quite half. For the reasons given, the value of the exportation cannot be accepted as a relative indication of that of the production. But regarding the latter in the most favourable light, it is very evident that the mining industry of Brazil, taken as a whole, is not showing results commensurate with the vast mineral wealth of the country. From 1700 to 1820, Baron von Eschwege,

basing his figures on the statistics of the tax on gold, states that the production during that period amounted to 530,000 kilos. Mr. Gorceix arrives at the production, from 1820 to 1888, of 658,228 kilos. Mr. Calogeras, in his admirable treatise on the mines, calculates the production until 1903 to be 944,000 kilos. Mr. Levasseur says that the production in the past of certain mines was almost unbelievable. Thus at the Gongo Soco, four litres of earth gathered in one day by a black miner, produced 10 kilos of gold. In sixteen days in 1829-30, 347 kilos of gold—to the value of over £44,000—were collected on the property.

THE GONGO SOCO MINE.

In the first quarter of last century, English capital began to flow into Brazil, and the Imperial Brazilian Mining Association acquired the Gongo Soco Mine in 1824 for £90,000, and only ceased working it in 1856 when the mine was flooded. Gongo Soco is a jacutinga proposition, and at the time of its flotation jacutinga was a mysterious formation—an unknown quantity about which " only Cornish miners knew everything and would brook no teaching." But Sir Richard Burton industriously collected all the information he could obtain on the spot about the formation. He concluded that the name was derived from the well-known Penelope, a handsome and fine-flavoured game bird called Jacu-tinga (P. Leucoptera) from the white spots upon its crested head and blue-black wings. " This substance of iron-black," he writes, " with metallic lustre, sparkles in the sun with silvery mica ; the large pieces often appear of a dark reddish brown, but they crumble to a powder almost black. The constituents are micaceous iron schist and friable quartz mixed with specular iron, oxide of manganese, and fragments of talc. Pieces of the latter substance, large enough for small panes, occur in blue clay

slate. The floor at Cocaes is fine micaceous peroxide of iron (specular iron), thin and tabular. This has never been reached at Gongo Soco, and the foot-wall is still unknown. It may be specular iron, for oligistic matter is found in small portions, and was stamped for free gold.

"Much of the jacutinga is foliated, and forms under pressure spheroidal oblong crystals never found perfect. It shows great differences of consistency; some of it is hard and compact as hematite, and this must be stamped like quartz. In parts it feels soapy and greasy, not harder than Fuller's earth; it is easily wetted and pulverised, but it is hard to dry. Its gold is readily separated by washing, and it is purified with nitric acid. The whole body of the lode is not worth removing; it is therefore best worked in underground galleries. The lines and veins are followed with pick and without blasting; their contents supply a soft and crumbling iron ore, which requires little stamping, and the 'line gold' thus produced is of superior quality. Often by following the filaments which radiate in all directions from a common centre, the miner finds a nucleus or nugget of large size, but inferior in standard to the line gold, and losing more in the smelting pot. The carat at Gongo Soco was 19—20. Some describe the gold as dark yellow with palladium, others say that it is deeply tinged with iron and coloured like lead. I have seen it of a bright brassy tint, and sometimes dingy red like worked unpolished copper.

"Gongo Soco evidently 'gave out' because men knew all about jacutinga. But in this mine the gold was free and the plundering was enormous, some say to the extent of one-half the find. Tales are still told of miners going out on Sundays carrying guns filled with stolen ore, and the tin biscuit-cases that came empty into the mine sometimes took out from it thirteen pounds of the precious dust. There is yet much treasure hidden, and at times the lucky ones find little fortunes in pots

and bottles. Gongo Soco is explained to mean 'the gong, or bell, sounds not.' Brazilians translate it 'escondrijo de ladroes'—den of thieves." Mr. Kilburn Scott refers to the "almost proverbial extravagance and robbery" attending the exploitation of the mine during the period that it was run by an English company.

By 1827 Gongo Soco had become an English village in the tropics, with its church and chaplain consecrated by the Bishop of London, and the original forty hands had increased to 180 Englishmen, assisted by 600 free labourers and blacks. In 1856 water entered the mine; the matrix was sopped to the foundations, and the workmen were drowned out—it was not the Brazilian miner only that had to quit when a mine became watered. "Gongo Soco died deeply regretted," remarks Sir Richard Burton; "it had spread itself into the branch mines of Boa Vista, Bananal or Aqua Quente, Socorro, Campestre, Catas Altas, Cata Preta, and Inficionado; it had fed and fee'd the country for thirty leagues around, and it had netted nearly £1,500,000."

THE JACUTINGA FORMATION.

Jacutinga, which presented a metallurgical problem that the early miners failed to solve, is a formation peculiar to Brazil, and on account of its many peculiarities and the difficulty of working it, this formation possesses special interest apart from the fact of its being the only known example of gold occurring under such conditions. Roughly speaking, it may be divided into two classes, the compact ore which requires stamping, and the soft ore which yields the bulk of its gold contents by the simple process of washing. These formations exist either separately or combined in a series of more or less parallel and irregular beds striking east and west with an underlie north or south of some 40 degrees. They have been proved to be auriferous at

various points for a distance of some 40 miles in a north and south direction, or at right angles to their strike. The beds are not all auriferous, nor is any single one auriferous throughout its length; but shoots occur in groups at certain points parallel with the bedding and lying in its furrows. They dip irregularly towards the east about 30 degrees, and contain gold unequally diffused throughout. In some shoots defined lines of gold or veins occur, which were followed downwards at the Don Pedro Mine for over 100 fathoms without any sign of their failing. Wherever the dip changes from a low to a high angle the shoots have become richer, and more or less they conform to the surface contour. English mining companies have endeavoured in past years to work this formation at Morro d'Agoa, Quenté, Bananal, Brucutu, Pitangui, Sao Miguel, Itabira, Gongo Soco, and Maquiné, but, as is stated elsewhere, success has only been achieved at the two last-named places.

OTHER EARLY ENGLISH COMPANIES.

In April, 1830, three years after the English acquisition of Gongo Soco, the St. John del Rey Company was formed. In due succession came the Cata Branca (1832-3), with the Morro das Almas in the municipality of Ouro Preto; the great Cocaes Company (1833-4), in Santa Barbara, including its branches Cuiabá, Caethé and Macuhubas, with its neighbour, Brucutu; and the short-lived Serra da Candonga Company, in the Serro do Frio, which ended after two or three years. Except Cocaes, which lingered on awhile, and St. John del Rey, these companies had all completed their careers by the year 1850. The failures affected the London market, and gold-mining in Brazil was looked upon thereafter with suspicion and disfavour. Here, as elsewhere in South America, the vast treasures promised by Montesquieu,

Robertson and Humboldt were realised to a certain extent and—diverted.

After 1859, when the St. John del Rey's Morro Velho Mine had rehabilitated speculation in Brazil—"which bore blame when she deserved every praise"—other companies cropped up. Minas Geraes had five: the Este del Rey, including the Lavras do Capao and the Papafarinha, near Sabara, and the Paciencia and Sao Vicente, near Ouro Preto; the Norte del Rey, in the Morro de Santa Anna, including the Maquiné Mine; the Anglo-Brazilian Gold Mining Company, Limited, at Passagem, near Marianna; the Rossa Grande Company, in the municipality of Caethé, and the Santa Barbara-cum-Pari, in the municipality of that name. "There is a sixth," writes Burton in 1868, "the Montes Aureos Gold Mining Company, Limited, established in Maranhao; but I see that it is already in the market. The total capital of these establishments is usually set down at £600,000. Only two, the Morro Velho and the Maquiné Mines, have as yet paid; the Passagem Mine has not paid, but probably will pay, and the rest have been failures—a dozen and a half losses to two and a half successes." In another part of his book, Burton writes that he has seen the Third Report of March 31st, 1866, of the Anglo-Brazilian Gold Mining Company, Ltd., and that he finds it "very satisfactory, promising a brilliant future. The works are only beginning; everything is on a small scale, and the speculation does not pay a dividend. But it is a 'likely' affair, which may still do great things, and I have no hesitation in considering it even now a half success."

THE PASSAGEM MINE.

The Passagem Mine is connected with the city of Ouro Preto, five miles to the westward, by a rough cart-road of steep gradients, but a railway, which is in

construction between Ouro Preto and Marianna, will pass within a mile of the mine, and, when completed, will facilitate traffic. The ore here occurs in quartz and arsenical pyrites, with smaller quantities of magnetic and ordinary pyrites, intercalated between friable itabirite on the hanging, and schistose quartzite on the foot-wall. The latter are sometimes interposed in the lode, and occasionally replace it altogether. The lode ranges in thickness between 2 and 15 metres, and contains varying proportions of gold. Near the foot-wall, where arsenical pyrites and tourmaline abound, it runs as high as 200 grammes, while the poorer ore yields only 2 or 3 grammes of gold per ton. In his report, dated January, 1914, Mr. Thomas Richards says: "The total longitudinal extent —north-east and south-west—of the ore bodies operated upon (with occasional intermissions of poor ground) has increased from about 2,000 ft. in the upper-shallow-levels, to nearly 3,000 ft. at the 680 metre level; and to the depth of about 600 metres the grade of the ore mined proved tolerably uniform at an average of not less than 11 grammes of gold per ton. . . . Unfortunately the ore bodies found in the lower portion of the mine, from the 590 metre level downwards, have with few exceptions proved shorter and narrower than at the higher levels; and a comparatively poor zone of ground has been found to exist between the 680 and 920 metre levels; so that notwithstanding the somewhat extensive developments of recent years, it has not been practicable during the past few months to extract the necessary quantity of sufficiently high-grade ore to cover the mining, milling and administrative costs." Under the heading of Prospects and Policy, Mr. Richards says: "Summarising the present position, I consider there is good reason to anticipate that the falling off in the grade of the ore during the past few months will prove to be only a temporary matter, and I am confidently of the opinion

that by increasing the output from the mine to not less than 7,000 tons per month—the quantity the existing mill is capable of dealing with—larger profits than hitherto realized may be secured. To effect this an extensive and vigorous policy of development must be adhered to, and with the increasing depth of the mine, this will necessitate the provision of additional machinery for hoisting, air-compressing, &c., which will entail a somewhat heavy expenditure of capital; but, although all mining is speculative, I consider this property sufficiently meritorious to warrant the necessary financial support."

The great explorer, Sir Richard Burton, was certainly correct in his estimate of the "likeliness" of Passagem as a mineral proposition. From 1865 to 1871 the mine was worked by the Anglo-Brazilian Gold Company, Ltd., employing old Brazilian wooden stamps and extracting only the free gold. But by this primitive method and in this period, 94,104 tons of ore were crushed, and gold was won to the amount of 22,715 ounces. From 1872 to 1884 the mine was more or less idle. In the latter year the property was acquired by the Ouro Preto Gold Mines of Brazil, Ltd., and placed under the management of Messrs. John Taylor & Sons. In the following year that famous firm started operations, and the results obtained up to 1914 are as follows :—

Ore crushed	1,625,965 tons
Gold won	561,903 ozs.
Value of gold	£2,156,480

THE ST. JOHN DEL REY PROPERTIES.

But the most famous of the existing companies engaged in gold mining in Brazil is the St. John del Rey, which was formed in April, 1830, and commenced operations in Brazil on mineral grounds immediately north of the city of Sao Joao d'el Rei (St. John of the King). As security for the gold duty being paid, the

licence granted to the company required a deposit fund of 50 contos of reis in Brazilian Government bonds, to be used by the Imperial treasury without paying interest. The deposits were found in a great lode parallel to a valley 1,320 yards long by 150 yards broad, and in small veins perpendicularly offsetting from it. The native workings had consisted of an open trenching, and the miners had opened an irregular quarry 110 ft. deep. Their pumping gear of bucketed wheels, each worked by eight or ten men, had failed, and the pit was soon filled up with mud and water to within 30 ft. of the edge. In August, 1830, an open-cut, adit-level, faced on both flanks with stone work, was begun from the rivulet side to the east. It proved the main lode, whilst its course cut the cross-veins below the depth reached by former miners. Moreover, it drained the surface water deposited during the rains. In those days the dry season above ground began in April, underground in July, and this gave but four clear months. The " shaft of St. John " was sunk about the same time in favourable ore ground, west of the quarry. On the east was commenced a second shaft for sump or drainage. Both served for ventilation, and were provided with gins for pumping and drawing stuff. Dams were erected to secure washing during the dry seasons, and dwellings, store-houses, offices, and other surface-works were put up. The management secured rights to water courses, and then commenced the normal operations of blasting, crushing and fanning in the *batea* (a pan corresponding with that of California and Australia), followed by the more scientific process of smelting and amalgamating the pyritiferous matter, which was forwarded to London for assay.

The total salaries for the first year amounted to £2,310. The works, however, did not pay; and in 1833, after incurring a loss of £26,287, the company's

representative made the move of his life when he transferred himself to Morro Velho.

MORRO VELHO MINE.

In 1834 the St. John del Rey Company acquired the well-known Morro Velho Mine, the purchase price being £56,434 12s. 7d. Before that date the mine had been worked in a rude primitive fashion in one huge excavation, the walls of which were supported by gigantic timber work and pillars. Since 1834 the workings have reached to 5,350 ft. vertically, and by 1916 the shaft should reach Horizon No. 20 at 5,826 ft. below the surface. On the pitch of the ore-body the workings have attained a depth of 7,600 (45 degrees decreasing to 40 degrees). In 1867 a fire and the collapse of the open-cut workings necessitated the cessation of operations and the sinking of two shafts, 1,122 and 1,422 ft. deep respectively. In 1874 work was resumed, but a second caving of the ground ensued in 1886, and the mine again became unproductive. Two new vertical shafts were sunk through the ore-body to a depth of 2,264 ft., this work being completed in 1892. Since then the mine has been developed by a series of internal shafts, each 1,200 ft. deep, in step-like succession, the first being started 610 ft. east of the main shafts sunk from surface, and each of the succeeding ones 1,420 ft. farther east, to be connected by a level parallel with the lode at a safe distance north of the country rock. " This method is in itself," writes Mr. T. A. Rickard, " an indication of the cautious policy of the manager, Mr. George Chalmers, who has never felt justified in looking sufficiently ahead to incur the heavy expense of a more comprehensive system of development."

According to the reports made by Dr. Derby to the St. John del Rey Company in 1901 and 1904, the lode lies in calcareous schist, which is older than the Upper

Silurian and possibly of even pre-Cambrian age. The schist, or calcareous phyllite is, in part at least, a sheared representative of an older eruptive rock intercalated within an ancient sedimentary series that has been highly metamorphosed in consequence of orographic movements of considerable extent. Granite intrusions, in the form of bosses and dykes, exist in the vicinity of the mine. The ore is mainly a massive mixture of pyrrhotite, with arseno pyrites and common pyrites. Quartz is a subordinate ingredient. The typical composition of the ore is as follows: Pyrrhotite 28·5 per cent., arseno pyrites 5 per cent., iron pyrites 6·5 per cent., quartz 24 per cent., carbonates of iron, lime and magnesia together making 36 per cent. Copper pyrites are usually present in a minor degree. According to the same authority the lode occupies a fault-plane dipping eastward at an angle of about 45 degrees, the shape of the ore-body being modified by systems of jointing in the schist.

The particulars of the property, which are given in the *Brazilian Year Book*, are as follows: "The mineral is very refractory in character, on account of the extremely fine state of division of the gold, which is locked up in the pyrites and only liberated by fine crushing. Recent improvements in methods of extraction, it is claimed, have brought up the recovery to over 90 per cent. The ore is a mixture of finely granular quartzite, dolomite and calcite, with mispickel, mundic, and traces of chalcopyrite. The last report states that there is fifteen years' reserve of mineral in sight, and there appears to be no reason to believe that this enormous ore-body, constituting a true chimney-lode, should become exhausted at any depth that can be economically reached. It is undoubtedly entitled to rank as one of the great gold mines of the world, and is, from the point of view of production, easily the premier mine in the country."

MORRO VELHO'S OUTPUT.

From 1835 to 1892 the output of the mine was 2,958,593 tons, yielding £5,167,592, or nearly 35s. per ton; while in the period from 1892 to 1913 the output was 2,715,933 tons, yielding £5,498,352 in gold, equivalent to 40s. per ton. In the first period 7·3 per cent. was rejected or sorted; in the second period only 5·7 per cent. The total output was 5,674,526 tons mined, or 5,313,028 tons milled for a yield of £10,665,944, which is equal to a yield of 39s. 11d. per ton crushed. The mine was unprofitable for the first five years; between 1842 and 1867 the total dividends and bullion tax amounted to £896,500; from 1874 to 1886 the profit was £556,600; from the re-opening in 1892 to 1913 the profit was £730,266, so that the total dividends and tax payments amount to £2,183,366. During the last period a bond interest of £277,700 has also been paid. From the commencement—according to a historical account prepared by Mr. George Chalmers, to whom I am indebted for the foregoing facts—about £1,000,000 has been raised for working capital.

Reviewing the history of the mine according to the three productive periods (1850-1865, 1875-1886, and 1900-1913), it is found that the working cost (not the total cost) ranged from 17s. to 23s. in the first period, from 26s. to 30s. in the second, and from 25s. to 31s. in the third. During these respective intervals the extraction in the mill has ranged between 52 and 80 per cent., 70 and 75 per cent., and 71 and 93 per cent. Dividing the history of the mine into two parts, before and after 1892, in accord with the statistics available concerning tonnage and yield, the extraction averaged about 65 per cent. in the early period and 87 per cent. in the late one, improving to 92 per cent. during the last seven years of the latter period. If these allowances are made

for loss in milling, it will be found that the 35s. per ton extracted from the shallower workings represented gold contents equivalent to nearly 54s. per ton as against the 40s. extraction and 46s. gold contents in the ore mined in the deeper workings.

"On the face of the evidence, allowing for difference in sorting," says Mr. T. A. Rickard in an extremely interesting paper on "Persistence of Ore in Depth," read before the Institution of Mining and Metallurgy in November, 1914, "it seems to me that the lode cannot be said to have become either richer or poorer as it has been deepened, and that the St. John del Rey is an example of persistence to great depth. Yet I consider that the experience of other mines warrants us in commending the cautious policy of the management, which does not assume the continuity of the ore-body for more than two or three hundred feet as measured at any time from the bottom level. If the ore-body follows a fold in the schist, it is obvious that similar folds along the strike of the schist may enclose other ore-bodies. Looking at the longitudinal section published in the reports, it is remarkable that so little exploratory work has been done outside the immediate limits of the known ore-bearing ground. Having regard to the unusual vertical extent of the workings, it would appear that lateral search for other ore-bodies is abundantly justified."

The following figures show, at a glance, the results obtained by the St. John del Rey Company up to February 28th, 1914:—

Ore raised	5,950,608	tons
Ore crushed	5,581,236	„
Gold won	£11,293,067	
Dividends and Tax paid	£2,247,563	

GOLD MINES WORKING IN 1900.

At the beginning of the present century eight gold mines—in addition to the Morro Velho and the Passagem

—were working in Minas Geraes, of which six were English and the other two were native ventures. The Faria Mine, belonging to the Faria Gold-mining Company, was situated near the station of Honorio Bicalho, on the Central Railway. The ore-body is a chimney or oval column, like that at Morro Velho, intercalated between micaceous schists, and consists of quartz and auriferous pyrites, with a certain amount of hydrated oxide of iron and argillaceous schist. The mine was opened up by levels run in along the centre of the lode from end to end and connected by rises. Powerful pumps were erected when the mine was sunk, which were able at the time to handle all the water, but as sinking went on the quantity so increased as to overpower them. The extraction by the cyanide treatment reached 90 per cent. on the sands and 55 per cent. on the slimes; and the proportion of concentrates, tailings and slimes were taken as 20 per cent., 30 to 35 per cent., and 40 to 45 per cent. respectively.

The Santa Querita Mine, worked by the Anglo-Brazilian Mining Company, is situated a short distance from the Sao Bento. The lode resembles and is probably a continuation of the Sao Bento lode, and the mineral it contains is irregularly distributed. The ore of the highest value is a concretionary limonite, and it was worked by a method of following the richer lines of the lode by means of levels extended from the hillside, in order to avoid the expense of haulage and pumping—ventilation being effected by air-shafts to the surface. The gold was recovered by amalgamation with copper plates in the mill and outside on tables, and the complete process gave an extraction of about 85 to 90 per cent., divided approximately as follows: 60 per cent. inside the mills, 15 to 20 per cent. on the tables, and 5 to 10 per cent. on the blanket-strakes, the total recovery being about 12 grammes of gold per ton of ore. The output of the mine averaged about 1,200 tons per month.

The Morro de Santa Anna Mine, distant about two miles north of the City of Marianna, and situated in the *buraco*, or hollow of Maquiné, was opened in 1862 by the Don Pedro North del Rey Company. The lode carries quartz, with arsenical and ordinary pyrites, and occupies the same geological position as that of the Passagem Mine, of which it is supposed to be the continuation. In 1865 the discovery of a rich outcrop on the adjacent Maquiné property, in which the gold was found contained in seams of jacutinga ore, similar to that of Gongo Soco, caused the rock mines to be abandoned and active operations to be commenced at Maquiné. Adits were driven, and developments underground disclosed shoots not known to exist at the surface, some branches being followed upwards and pieces of gold being taken out from under the roots of the turf. During 1868, 2½ tons of gold were extracted (one lot of 103 tons of ore gave 127 kilos of gold), the average gold value of the ground being 15 grammes per ton. For three years in succession —1867, 1868 and 1869—the company distributed over 100 per cent. in dividends. Deeper drainage then became necessary, and after several failures to drive adits through a belt of flucan, which crossed the property, an adit some 200 fathoms long was completed. The water difficulty, however, was constantly increasing, and, though the pumping arrangements succeeded for some time and allowed of a depth of 50 fathoms being attained on the incline, under adit, the machinery never had the command of the water below the 30 fathoms level. Consequently, what with the breakdown of expensive machinery, the re-opening of flooded workings in treacherous ground, and the difficulties attendant upon obtaining mineral under such adverse circumstances, the company were compelled to suspend operations in 1880, and the property was abandoned at a depth of 212 metres on the dip. The Maquiné and the Gongo Soco had so

much in common that the history of one may be read as that of both. Moreover, they were the only two jacutinga mines successfully worked by English capital.

Upon the abandonment of the Maquiné Mine, attention was again directed to the original Morro de Santa Anna property, and, for the treatment of the ore, a 20 California stamp plant, with Frue vanners, and a 5-ton Plattner chlorination plant were erected. The value, thickness, length, &c., of the lode are described as much the same as those of the Passagem Mine. Unfortunately the capital of the company was insufficient to develop the mine satisfactorily, and the property was sold to the Ouro Preto Gold Mining Company.

The Itabira Mine is one of a group of three properties situated near the City of Itabira do Matto Dentro, which the General Brazilian Mining Association was formed to acquire in 1868. The principal mine is that of Itabira, in which the gold is contained in thin seams of jacutinga, interstratified between the siliceous iron schist and an enormous mass of massive itabirite, but all three properties were worked with great profit during the eighteenth century. The General Brazilian Company's efforts failed to reach the auriferous seams, and when the concern went into liquidation in 1874, the property was acquired by some of the original owners, who continued the work and crossed the seams a few months later. In four subsequent months they extracted 2,292 ozs. (Troy) of gold, worth £6,000. The gold was nearly all found in very rich stringers of jacutinga, the ore from which was treated on small canvas strakes and in *bateas*, while the poorer parts of the seam were treated in a stamp-mill of native manufacture. A heavy fall of rock in the shaft ultimately stopped operations and the mine was abandoned.

The Carrapato Mine, floated by the Carrapato Gold Mining Company, is situated near Caethé. Its lodes are

for the most part of quartz and auriferous arsenical and ordinary pyrites, interstratified between talcose schists. The largest lode, varying in thickness between 2 and 5 metres, assayed in an average sample 12 grammes per ton, but the highest gold values were found in a series of lenticular masses of quartz, from 0·5 to 3 metres in thickness, and frequently containing visible gold at the contact with the country rock. Samples of these taken by Mr. Kilburn Scott, to whom I am indebted for many of these particulars, gave 78 grammes per ton of ore.

The Juca Vieira Mine, situated close to the Carrapato property and the Florisbella Mine, near the station at Honorio Bicalho, are both owned by native companies. In the Juca Vieira, the gold-bearing formation resembles that of the adjacent Carrapato Mine, but containing more visible gold and some sulphide of antimony. The Florisbella area contains several lodes of quartz, interstratified with micaceous schists. A sample taken from a shaft running through one of the shoots gave the high gold contents of 157 grammes per ton, but the general run of the ore varies between 8 and 20 grammes.

THE SAO BENTO GOLD ESTATE.

The Sao Bento Gold Estates Company, working under the most adverse circumstances, won from the higher levels of their property, during a period of 5½ years, no less than 62,683 ounces of gold and 5,130 ounces of silver, valued at £266,111 16s. 6d. In 1902 the mine showed a net profit of £15,000, but the enormous cost of transport—the property was then 50 miles from railhead at Sabara—the inadequacy of motive power and of plant, and the lack of a roasting furnace, formed an accumulation of obstacles which the management were unable to surmount, and the company went into voluntary liquidation. For three years the property lay idle, and it was

then acquired by the present Sao Bento Syndicate, who are exploiting the estate with every promise of success. From the reports by Messrs. Bainbridge, Seymour & Co. (April, 1910) and Mr. James Miller (September, 1913), it is seen that the estate has a total area of about 9,500 acres, of which the Sao Bento Mine occupies 3,000 acres. The adjoining Corrego do Onca area of some 6,500 acres carries abundant timber for mining purposes, while at Pity, 9½ miles from Sao Bento, the Syndicate has a further 80 acres upon which a very complete hydraulic installation has been erected capable of supplying the mine and mill with far more power than they are likely to require. The whole of the property is well provided with water, and a pumping station erected on the Sao Joao River is capable of raising 250 gallons per minute to a height of 200 ft. This plant is connected with the mill tanks by 2,000 ft. of 5-in. piping. The Central of Brazil Railway completed in August, 1912, the extension of their line alongside the property, which is now within 100 ft. of the station of Sao Bento. Before the line was constructed it took from fifteen days to six months, according to the condition of the roads, to haul machinery from Sabara to the mine at a cost, to the former company, of £7 per ton. The transport of freight now occupies 2½ hours, and the cost has been reduced to 7s. per ton.

The exact nature of the Sao Bento country rock has not been determined, but in the vicinity of the mineral lodes in the oxidised zone, the rocks themselves so closely resemble lode matter that it is difficult to separate one from the other. The mineral lodes lie conformably with the country rock, and are traceable by their outcrops for miles with but few breaks. In the unoxidised zone the filling matter of the fissures consists essentially of quartz, arsenical pyrites and iron pyrites, with but small quantities of the enclosing slate. Where decomposed, the pyrites are replaced by ferruginous gossans

accompanied by quartz and clayey minerals. The gold in depth mainly accompanies the arsenical iron pyrites, both of which occur in seams and veins in the quartz, varying in width from a fraction of an inch to 4½ ft. of solid sulphides. The values in the ores, which are entirely free of copper and zinc, are entirely confined in gold, the silver being of no commercial value.

Of the five lodes on the property, practically the whole of the development has been done in the Sao Bento lode. The present workings are situated in the central portion of the estate beneath the highest point of the hills, where former workers made large excavations, extracting the easily-treated surface ore through adits driven into the hillside. In more recent times systematic mining has been carried down to No. 11 level, which is 1,160 ft. below the surface at this point, being the deepest adit that can be worked to advantage. There are two sections of the mine, the No. 1 and No. 2 ore-bodies, which have been worked down to the No. 11 level. Messrs. Bainbridge, Seymour & Co.'s statement of ore standing in the mine, together with its corresponding assay value (made in 1910) was: Tons in sight, 65,235; value per ton, 9 dwts. 20 grains; probable tonnage, 28,613. Mr. Miller's estimate, made in 1913, was: Tons in sight, 60,000; value per ton, 8 dwts. 12 grains; probable tonnage, 28,666.

In addition to possessing a large area of mineral land, the Sao Bento Mine has been well and systematically developed, exposing a body of payable ore on No. 2 ore-body sufficient to supply the mill at the rate of 100 tons daily for two years, while another year's supply can be speedily added to the reserves by the continuation of the present developments. In spite of its refractory nature, the treatment of the ore presents no great difficulty, and although the grade is low, it is anticipated that 90 per cent. of the gold will be recovered. The power

plant at Pity is in itself a valuable property, for, once Sao Bento has demonstrated that the sulphide ores can be treated at a profit, other mines in the district will undoubtedly recommence work, and they will look to Pity to supply them with power. "In conclusion," Messrs. Bainbridge, Seymour report, "we are of opinion that the Sao Bento is a valuable property, not only on account of the mine proper, but from the fact that the undeveloped resources of the estate offer an extensive field for further profitable investment of capital." This conclusion is corroborated by Mr. James Miller, who writes that, "having regard to the now favourable position of the mine, the persistency of the ore chutes in depth, and the width and value of the same, together with the fact that the successful treatment of the ore depends entirely on the erection of a roasting furnace of sufficient capacity to cope with the daily production of concentrates, an ample supply of labour at reasonable rates and abundant cheap power available at all seasons of the year, I am of opinion that the property, under judicious and careful management, offers favourable prospects of good and steady returns for many years."

THE CONQUISTA-XICAO GOLD ESTATE.

The gold-bearing properties known as Conquista-Xicao comprise an area of some 2,000 acres of country, which occupies the whole of a plateau in the Sapucahy Valley, about 10 kilometres north-east of the town of Sao Goncalo, in the State of Minas Geraes. The plateau is bounded by the Rivers Barretos and Conquista, and rises more than 400 ft. at its highest point above the level of the junction of those rivers. The main quartz ledge of decomposed quartz has been submitted to repeated assays and analyses made in Rio de Janeiro, Paris and New York, which have shown it to contain

8 dwts. of high standard gold, without a trace of either arsenic or antimony. Mr. L. H. De L'Espee, an American mining engineer of New York City, who worked the mines for a while on a moderate scale, proved the average yield of gold to be 1¾ dwts. per cubic metre, valued about 6s., and he estimates the total body of ore present in the property to amount to at least 5,175,000 cubic metres, yielding 453,330 ozs. of gold, worth £1,632,000. The ledge formation extends beyond the limits of the property to Barro Alto (6 miles from Xicao, on the western side), Cajuru (over 20 miles south-east of Conquista, on the eastern side), and Sta Luzia (1½ miles to the north-west). The formation at each of these three places appears to be identical, and guarantees the continuity of the ledges. The comparatively recent discovery of the auriferous properties of the district explains the insignificant amount of work done by the natives. The most interesting development was accomplished in the past on the Xicao side of the estate by Captain Vicente Xavier, who, in the course of a quarter of a century, obtained a considerable production of metal. But his activities were not more than scratches upon the ledge, which extends within the Conquista limits for a length of 650 ft., with a breadth of 330 ft.

When the estate was acquired by the Conquista-Xicao Gold Mines, Ltd., they became possessed of a practically virgin territory, which required a complete installation of plant and machinery for its development, the construction of dams and reservoirs, and the repairing and extending of the narrow gauge railway running from Campanha to Sao Goncalo de Sapucahy, which links up with the mines. All this involved a large expenditure of time and money, and the work was considerably impeded by the delay in the delivery of material and the defalcation of the *concessionnaries* who were constructing the railway, with the result that the company were compelled

to acquire and complete the line in order to obtain absolute control of the connections. But all these difficulties have at last been overcome, and the latest advices from the property state that the dams, water mains, elevating and generating works are constructed, the fitting up of the turbines, electric plant, pumps and monitors, sluices and tables, reservoirs and power transmission lines is finished, the houses for the accommodation of staff, workmen and stores are built, and every requisite for the successful working of the property is completed. The pressure mains have been tested with entire success, and according to the manager's report, the turbines and pumps are working well, the motors are giving the necessary power, the reservoir has been filled, and excavations are being commenced on earth which has been washed down by the rains for several years and, in consequence, is almost sterile. Actual experimental work on the property, after many vexatious delays and disappointments, is now proceeding, and every hope is entertained that the exploitation of the properties will justify the labour and cost that have been expended upon them.

BRAZIL, A QUEEN AMONG NATIONS.

In the handsome and exhaustive *Twentieth Century Impressions of Brazil* (1913), acknowledgment is made of the prominent part that English capital has played in the gold-mining industry of the country. Levasseur tells us that some 35 mining companies, nearly all English, possess important concessions in the Republic, " but the majority, still in the preparatory period, content themselves with economic working or are waiting on events." Yet there are everywhere indications that when the necessary mining legislation shall have been enacted, there will be an access of activity in all the productive industries of Brazil, with concomitant general develop-

ment of her mineral resources. "The field for mining operations is immense," says the *Twentieth Century Impressions*, "its divisions are many, and well-directed developmental efforts should prove highly remunerative to the original prospector as well as to companies formed to exploit the subterranean wealth." Mr Savage Landor, who travelled through the country from east to west, declared that only the enthusiasm caused by what he saw in his journeyings in the unknown regions prevented him from succumbing to the hardships and practical starvation he experienced, and he spoke of the day which awaits Brazil when she will stand revealed, "by means of her natural riches still undeveloped, a queen among the nations."

The conclusion expressed here, that it is in her future and not in her past that Brazil's part in the mining history of the world chiefly lies, has also been subscribed to by Mr. E. M. Touzeau, who in concluding his temperately worded paper on the subject, "ventures to suggest that the interest which attaches to gold mining in Brazil is not so much due to what has been done as to the possibilities of the country as a field for future work. Regarded in this light, it will be found of much greater interest and importance than the record of what has been, up to the present, a mere surface scratching of a huge territory."

RIVER DREDGING.

Writing in 1902, Mr. Kilburn Scott stated that a detailed investigation of the alluvial deposits of Minas Geraes and the old methods of working them, had convinced him that the important deposits in the beds of the rivers are to all intents and purposes still virgin. To the early explorers the task of exploiting the beds of rivers was well-nigh impossible, but to-day there is nothing to prevent the overcoming of all difficulties by

modern machinery. That gold exists in considerable quantities in the beds of these rivers is undoubted. Almost everywhere the *faiscadores* (*batea* washers) gain a livelihood by working the river banks during the dry season, and coffer-dams, constructed in the shallow margins of the rivers, enabled the early miners to get at some of the gold. In the majority of cases, however, three-fourths of the total area of the river-beds have remained untouched. Mr. Scott is of opinion that river mining would be profitable if carried on with suitable modern machinery. Owing to the depth of water and the irregular size of the gravel, the hydraulic elevator or centrifugal pump would not be applicable, and he suggests the employment of a modification of the bucket-dredger. Large boulders and dead tree-roots—the bug-bears of river-mining—are not likely to be encountered, while sufficient fuel for the necessities of the machinery could easily be obtained, or power could be transmitted electrically from some neighbouring waterfall. It would of course be necessary to exercise great care in prospecting the rivers and studying the conditions of work, in order to select apparatus thoroughly fitted to local peculiarities and requirements. As far back as fifteen years ago the State Government had granted several concessions to work the river-beds in the auriferous zone, but up to the present no dredges have been set to work in Minas Geraes.

Mr. Touzeau also refers to washing in the rivers and streams which had also produced a large amount of gold in the past. "Even now," he writes (1892), "it is very common to see a native, knee deep in the water, raking up the bottom with a hoe, so that the disturbed dirt may flow through the little race he has made and over a few pieces of bietta upon which he may hope to arrest a few particles of gold as a reward of his day's work. It was a common practice in the slavery days to send out

individual slaves on such a mission, taxed to bring in a vintem of gold in a quill as the minimum of a day's work."

"A HEART OF GOLD IN A BREAST OF IRON."

In another part of his paper on "Gold Mining in Brazil," Mr. Touzeau finds fault with a simile which Mr. Henri Gorceix employs in summing up the mineral region of Brazil. "The Province of Minas Geraes," says Gorceix, "may be fitly described as a heart of gold in a breast of iron." Mr. Touzeau comments that "the simile only fails in its omission of reference to the wide range of mineral wealth which Mr. Gorceix himself has pointed out that it possesses." The late Director of the School of Mines at Ouro Preto was a very distinguished French scientist, and his survey covered every mineral that exists in the Republic, but he recognised that her principal assets were contained in her deposits of gold and iron, and he did not hesitate to indicate that of these, iron was the more important.

His judgment has been endorsed by other scientific and practical experts, including the Manager of the St. John del Rey Mining Company, who in his 1914 Report makes these significant remarks: "All the first-class iron lands for a radius of many miles from this mine have now been bought up, principally by foreign capital. A few have changed hands of late at exceedingly high prices compared to the original purchase prices. . . .

"The consumption of the high-grade ore of the fields close to the great smelting centres is rapid, and as these become demolished, in spite of some success having been made in the concentration of low-grade ores at those places, the rich ores of this locality become daily more valuable, and will undoubtedly in time be one of the most valuable assets of this Company."

SAO VICENTE ESTATE AS AN IRON PROPERTY.

A similar opinion concerning at least one other gold and iron property, the Sao Vicente, situated near the St. John del Rey area, is held by Commander F. V. Lockey, R.N., who was in Brazil as the representative of Sir John Jackson, Ltd., the well-known contractors. In writing his report to the owners of this property, Commander Lockey says: "The estate undoubtedly contains gold, but I am more interested in it as an iron ore proposition, for which class of properties there is a very keen demand in Brazil. . . . I may say that it is only through the introduction of electricity that it will be possible to make iron ore a payable proposition in the State of Minas. The expense of taking the ore to the coal or the coal to the ore is prohibitive, but now that electricity can be generated by water power, the difficulty can be solved, and all the power required can be generated from the waterfalls on your property. I leave it to others to speak as to the gold-bearing qualities of the property. From local information which I obtained, and from people who I should think are well qualified to speak, the property contains millions of tons of 6 dwts. gold ore. I believe it does, but it is as an iron ore proposition that a large and immediate return can, I think, be made."

The Sao Vicente Estate, belonging to the Parral Mining Corporation, Ltd., with its area of about 25 square miles, or 16,640 acres, is situated some 12 miles from the Station of Itabira do Campo, on the Central of Brazil Railway. The property was worked to a depth of 200 ft. by the original Brazilian miners, and when the mine became watered the workings were in a large body of ore—nearly 40 ft. wide, going at least 1 oz. of gold to the ton—which traverses the estate for a distance of 4 miles. It is situated midway between and on the same auriferous belt as the St. John del Rey Company's Morro Velho Mine and the Passagem Mine of the Ouro Preto

Company, and Captain J. Eslick, for many years the chief underground manager of the former company, states in his report upon Sao Vicente: "I have no hesitation in saying that if the mine be lengthened westward from a vertical shaft, and worked on the same principle as the St. John del Rey, it will prove equally successful, and turn out as good a mine as the St. John del Rey." Another St. John del Rey authority, Mr. Richard White, who was amalgamation officer for that company for fifteen years, writes: "The Paciencia Mine (one of the seven mines in the Parral Corporation's group) was left wonderfully rich, millions of pounds' worth of gold having been sent away from the whole of the property, and with proper machinery millions more will be divided amongst those who are fortunate enough to take it up." There is an abundance of timber available and sufficient water, in the estimation of Messrs. André Griffiths, Mannheim and Co., to provide in the aggregate "at least 500 h.p.," while Mr. Walter Ness, the Scotch mining engineer, reports that "if the mine were properly fitted, and the water power brought into it by completing the watercourses, it might be made a better paying concern than the St. John del Rey." But as the St. John del Rey Company, after winning over eleven and a quarter million pounds' worth of gold from their property, are now contemplating its future as an iron proposition, it is, I believe, the intention of the Parral Corporation to work the iron deposits upon their huge area in the first place, and, as it is proposed to do in the case of the neighbouring properties of Itabira do Matto Dentro, to make the gold-winning operations secondary to the iron.

FIRST DISCOVERY OF IRON IN MINAS GERAES.

The first recorded discovery of ferriferous deposits in Brazil was made towards the close of the sixteenth century, and in 1597 the Portuguese Government of the

country despatched miners to work the mineral in conjunction with gold and silver. Probably the few small forges that remained in activity until the first quarter of the seventeenth century turned out the first iron produced in South America. The mountain bearing the native name of Ipanema, in the State of Sao Paulo, is associated with the earliest history of the iron production of the Republic, but in the early part of the eighteenth century the deposits of Minas Geraes had received attention, and the enterprise displayed at that period in search for gold was generally coincident with undertakings specially designed to promote the development of the iron resources of that State. It has since been found that iron exists in every State in Brazil, and in sufficient quantity to supply the world's demand for generations to come, although the estimates as to the total quantity are not agreed.

The iron ore field of Brazil is situated in the State of Minas Geraes, within a zone of about 3,200 square miles, 3,280 to 500 ft. above the level of the sea, and about 310 miles from the nearest port of Rio de Janeiro. The principal ore outcrops commence at Congonhas do Campo, extending towards Ouro Preto and on through Antonio Pereira, Infecçionado, Agua Quente and Caraça. From the latter place there is a break to Itabira do Matto Dentro, where the ores again outcrop very strongly, and so continue to the Gaspar Soares Mountain, where iron was first made in the State by the direct process in 1815. Another series of mountains through which the iron ore stratum runs, extends from the Pico d'Itabira do Campo, through Taquaral, Piedade and Cocaes. The zone is crossed by the Central Railway, the most important line in Brazil, built with a wide gauge of 1·60 metres, to a place named Lafayette, on the borders of the ore field, where it is broken to 1 metre, owing to the mountainous character of the country. Other important deposits of

iron ores also occur in different parts of the State: at Barbacena on the Central Railway and Viçosa on the Leopoldina Railway, as well as in the neighbouring State of Sao Paulo, where, at Ipanema, a deposit of magnetite has been worked more or less intermittently from the end of the sixteenth century.

THE IRON ORE DISTRICTS OF MINAS GERAES.

In *The Iron Ore Resources of the World*, an inquiry made upon the initiative of the Executive Committee of the Eleventh International Geological Congress, held in Stockholm in 1910, and published by the Congress, Dr. Orville Derby contributed the chapter on the "Iron Resources of Brazil," in the course of which he says: "Limiting ourselves to the districts regarding which definite information is at hand, it may be said that these belong to the States of Minas Geraes, Bahia, Goyaz, Sao Paulo, Parana, Santa Catherina, Rio Grande do Sul, and Matto Grosso. The ores known in the first three and the last of these States are predominantly hematites; in the others predominantly magnetites. With a single exception none of these ore districts have been studied in a way to give the definite information desired for the proposed discussion on the subject of iron ore supply by the International Geological Congress. For the most part our knowledge of them is limited to the mere fact of their existence, their approximate geological position, and the outward aspect of the ore picked up by unskilled observers. These almost invariably report enormous quantities ('whole mountains' is the usual phrase) of most excellent ore, and in many cases it may be presumed that these statements may eventually be proved to have some foundation in fact, but, for our present purposes, such districts must be left entirely aside."

The above-mentioned "single exception" is the district of the eastern central part of Minas Geraes, which

Dr. Derby considers the only portion of Brazil that may be said to make a definite and proved contribution to the world's resources of iron ore. " In its essential geological features," writes Dr. Derby, " the region is constituted by a basement of complex of crystalline schists (gneiss, mica, amphibole, chlorite, and talcose schists) much injected with granite, and overlaid by a heavy series of partially metamorphosed sedimentary beds, profoundly folded and faulted. In this series, which consists principally of quartzites and clay slates with subordinate beds of limestones, a prominent member is the peculiar iron-bearing quartz to which the name of itabirite has been applied. This shows all possible gradations from an almost pure quartz rock with scattered flakes of hematite to a massive hematite free from quartz. The latter presents itself as intercalated layers, or lenses, varying from a few milimetres up to scores of metres in thickness, alternating with leaner quartzoze portions. When limestones occur in the series, they are also more or less heavily charged with flakes of hematite, and are frequently associated with commercially valuable ores of both iron and manganese. Taken as a whole the itabirite beds, which are often of great thickness, become, when exposed to the weather, extremely friable, and as the region is one of heavy rainfall (1,500 to 2,000 milimetres) they have been extensively denuded. In consequence of this the massive portions, when they occur, stand out as prominent topographic features; the rain and wind swept slopes become covered with a rubble of iron ore due to the breaking up of the thinner intercalated layers, more or less completely freed from the associated siliceous elements by rain and wind action, and the bottom lands of the valley become charged with deposits of iron sand separated by the natural sluicing of the streams.

" There are thus produced from the same series of beds three classes of ore :—

Quarry ore in the peaks and other natural exposures *in situ* of the massive portions of the rock;
Rubble ore on the denuded surfaces; and
Sandy ore in the valleys where sluicing action has taken place.

"To these must be added a fourth class, the so-called 'canga' (contraction of tapanhoacanga—negro's head), due to the cementation by limonite of the rubble ore into a hard ironstone conglomerate. It is probable also that still a fifth class might be recognised in the outcrops of quartz hematite rock, sufficiently friable to permit the separation of the metallic mineral by sluicing. . . .

"As regards the quality of these ores, the existing analyses are naturally of hand specimens only, but all mineralogists and metallurgists alike, who have examined the outcrops, agree that on immense rock faces, such as represented in the peak of Itabira do Campo, no differentiation of richer and poor portions are perceptible to the eye.

"Most of these analyses are deficient from an industrial point of view, as in the majority of them the phosphorus contents is vaguely given as 'traces' without accurate determination; and no reference is made to titanium, leaving it doubtful whether this element has been especially looked for or not. The oxide of iron contents is generally given as from 67 to 69·5 per cent., the remainder being almost exclusively silica. In two cases in which, at the writer's suggestion, special tests were made for titanium, none was found, and from this and other considerations it seems safe to assume that as a class these ores are practically free from it.

"The most reliable phosphorus determinations at hand are from samples, from two different localities, submitted to the Krupp works and to those of the United States Steel Corporation, both of which gave the same result, namely ·0024 per cent. In this connection it

may be mentioned that some years ago the writer was consulted by the eminent French metallurgist, Mr. F. Gautier, who was then in charge of the Esperanca Works working on rubble ore from near the Itabira do Campo peak, as to where he could obtain for admixture an ore higher in phosphorus.

" In short, the quarry ores of the district here considered may be safely set down as existing in immense quantities and as of high and, within certain limits, uniform quality.

" As no special study has been made of the other classes of ore of this district, very little can be said of them beyond the fact that they exist in immense quantities. From a practical point of view it is probable that, with the exception of the rubble class, they should only be considered as reserves for the future, or as contribuents to a limited extent as admixtures.

" As regards origin and composition, the rubble class of ore is practically identical with the quarry class. In mining it would naturally be impractical to free the high-grade ore entirely from an admixture of earth and pebbles of lower-grade ore, and this would somewhat reduce the metallic product, but this reduction would, presumably, be more than compensated, in most cases, by a reduced cost of mining and transportation, since in general this class of ore lies in more favourable positions than the other. Thus, from an industrial point of view, it seems tolerably safe to set the rubble ores down, as regards quantity and quality, as comparable with those of the quarry class.

" The ' canga ' class of ore is naturally of lower grade than the others, owing to a greater or less admixture of fragments of quartzose and argillaceous rocks which it would be impracticable to separate in mining, and to the presence of water in the characteristic limonitic cement. Good observers estimate the mean iron contents of this

class of ore at about 50 per cent. As already remarked, the apparent quantity of this class of ore is immense, and, as far as can be judged by a simple ocular inspection, probably in excess of that of any other class.

"From lack of definite information regarding the deposits of sandy ores, and of the technical conditions in which they could be utilised, this class must be left out of account in the present brief sketch. Suffice it to say that should a demand arise for this class of ore, the district in question could supply it in great quantities."

OTHER BRAZILIAN IRON ORE DEPOSITS.

Apart from the district comprised in the eastern central part of Minas Geraes, and of its various prolongations, which Dr. Derby discusses in the foregoing passages, hematite ores are known to exist in various other districts of the State of Minas and in several other States of the Republic. On the subject of such other deposits the same eminent authority says: "These are generally considered, in most cases without sufficient evidence, to be substantially identical as regards geological conditions with those above described. Nothing is definitely known regarding their extent, but those of the western part of the State of Minas, the central part of the State of Goyaz, the Sao Francisco region of the State of Bahia, and the Carumba district of the State of Matto Grosso are presumed to be extensive.

"With the present means of transportation, or with those that are likely to exist in the near future, the greater part of these deposits must be regarded as inaccessible. The exceptions are those situated along the River Sao Francisco in the State of Bahia and near the banks of the River Paraguay in Matto Grosso. The former can be reached by 575 kilometres of railway from the port of Bahia to Joazeiro, and by a certain amount

of river transportation up stream from that point, and also by 1,010 kilometres of railway from the port of Rio de Janeiro to Pirapora and down-stream navigation from that point. The Matto Grosso ore deposits, situated in the Urucum Mountains, are about 30 kilometres distant from the seaport of Corumba, which is 3,197 kilometres distant from the seaport of Buenos Aires, in the Argentine Republic.

"The iron-ore formation, seen many years ago by the writer at various points along the River Sao Francisco, is believed to be identical with that of Minas Geraes, and some of the deposits may prove to be comparable with those above described as regards quantity and quality, but on this head nothing definite can be said as the examination was of the most cursory character. That of Urucum, in Matto Grosso, occurs in association with manganese ores and with limestone, and, in this respect, offers a certain analogy with that of Minas Geraes, but it differs in the fact that the siliceous admixture, where it occurs, is in the form of jasper rather than that of granular quartz. The deposits are reputed, on good authority, to be extensive, but the quality, judging from the chance specimens that have come to hand, is not as high as in the Minas Geraes ores.

"As already remarked, magnetite is a very widespread mineral in Brazil, and many of the occurrences are reputed to be extensive. The most accessible and, so far as known, the most extensive of these occurrences are situated in the coast region of Southern Sao Paulo, Parana and Santa Catharina. Of these the only one known personally to the writer is in the first of these States, and is too highly titaniferous to be industrially available. Various other occurrences that are only known by hand specimens and the statements of interested parties partake, though in a less degree, of the same defect, but among the samples examined are some

of a manganiferous type that seem to be promising. Nothing, however, is definitely known regarding the economic conditions of this class of ore. The districts tributary to the ports of Paranagua, in the State of Parana, and of Sao Francisco, in that of Santa Catharina, are well worthy of examination in this respect, as there is a reasonable probability that workable deposits of good ore may be found in them, and in this case their proximity to the sea-board would give them a great advantage over the known deposits of hematite ores."

BRAZILIAN AND LAKE SUPERIOR IRON ORES COMPARED.

In the course of an extremely clever and much-quoted article on " Hematite Ores of Brazil and a Comparison with Ores of Lake Superior," contributed to *Economic Geology* (1911), Messrs. Leith & Harder confirm the essential results of the work of Dr. Derby and Dr. Gonzaga de Campos, and supplement the accounts given by those geologists with new matter relating to the origin of the ores and their comparison with Lake Superior iron ores. They classify the Brazilian ores as follows :—

Bedded Ore.

Thick bedded massive hematite (dense, hard, blue hematite ; fine specular hematite ; coarse specular hematite ; martite).

Thin bedded laminated hematite or jacutinga (fine grained or crystalline ; hard or soft).

Fragmental Ore.

Canga.

Rubble Ore.

Sand Ore.

Secondary Ore.

Leached carbonate ; enriched itabirite.

A comprehensive examination of each of these classes of ore enables these well-known mining engineers to show

that "the important ores in this district are massive hematite and jacutinga. Secondary concentration, resulting from the leaching of impurities, has enriched much of the jacutinga ore, but has not been sufficient to form ore deposits from ordinary ore formation or itabirite as has been the case in the Lake Superior district. Brazilian ores are associated with vast quantities of residual or transported fragmental ores, and therefore not to be immediately utilised, but still constituting enormous fair-grade deposits for the future. Parts of this ore not cemented are locally as rich as the massive ores, and will be early utilised. Because of glaciation, the counterparts of the fragmental ores are not abundant in the Lake Superior region. . . . The grades of these hematites vary, of course, with the content of silica and phosphorous, but the conspicuous thick lenses of massive iron ore are probably the richest ores of Bessemer hematite in the world. Some jacutinga ores are equally rich, but others are somewhat high in phosphorous and silica. The canga ores are somewhat lower grade than bedded ores, because they are cemented with clays and hydrated hematites, carrying a larger percentage of phosphorous and silica than the bedded ores. Large areas of these ores will average 50 to 60 per cent in iron."

An interesting description of the origin of the various ores prepares the reader for the following valuable comparison of the Brazilian ores with those of Lake Superior: "The rich and important Brazilian massive hematite and jacutinga ores seem to be the result of direct sedimentary deposition, as more or less hydrated hematites without much impurity, which have since been more dehydrated and have required no extensive secondary enrichment to make rich ores out of them. Counterparts of these in the Lake Superior region are relatively insignificant, the nearest counterparts being the specular

hematites of the upper parts of the Negaunee formation in the Marquette district of Michigan, and the hard, blue hematite of the Soudan iron formation at the Minnesota Mine in the Vermilion district of Minnesota, but both of these have suffered secondary concentration. In each of the sedimentary iron formations of Lake Superior there are certain layers originally richer than others which have required less secondary enrichment than others to make iron ores from them, but in all of them more or less conspicuous secondary concentration has been necessary to make ores even from the richer layers. Furthermore, the evidence is good in the Lake Superior region that the original iron formation was deposited dominantly as ferrous compounds (iron silicate and carbonate), which may have been oxidised, rather than being deposited directly as ferric oxide.

"The porous portions of the jacutinga beds, the leached carbonate, and the replacement deposits of manganiferous iron ore of the Brazilian field, represent a secondary enrichment essentially by the leaching of carbonate and silica and by oxidation and local transportation of the iron, this secondary concentration being similar in all essential respects to that which has produced the Lake Superior hematites. In porosity and slumping, due to leaching of carbonate and silica, the ores are similar in appearance to those in the Lake Superior region. They are on the whole much less hydrous and are more crystalline. In the Brazilian fields the leaching of silica is much less extensive, however, than in the Lake Superior district, for the reason that the silica to be leached is largely in the form of coarse quartz sand and locally recrystallized under the influence of dynamic metamorphism and intrusion, each individual presenting relatively small surface in proportion to its mass, and therefore being with difficulty dissolved by the percolating waters. In the Lake Superior iron formation the silica

is in the form of fine chert, presenting large areas in proportion to mass and being leached much more readily. The fact that so little of the silica in the itabirite has been dissolved and transported may be partly due to this. The concentration of the jacutinga is apparently largely due to the leaching of carbonate.

" The fragmental ores, formed by ordinary processes of weathering and erosion, probably were at one time present in the Lake Superior region in enormous quantities as they are now in Brazil, but erosion represented by the pre-Cambrian unconformities and glaciation has removed them. The only counterparts of these ores in the Lake Superior region to be found now are in conglomerates at the base of series resting on iron formations.

" It thus appears that each of the principal classes of Brazilian iron ores has its counterpart in the Lake Superior region, and that much the same processes of ore concentration have been active in both districts, but that the relative effectiveness of these processes and their results have differed in the two districts. In the Lake Superior district primary sedimentation was not sufficient to produce iron ore. Important secondary concentration was the essential and controlling factor. In the Brazil region, primary sedimentation produced abundant and rich ores ; secondary concentration was a minor factor, only locally important in developing ores.

" It follows, therefore, that in the Lake Superior region the important considerations in exploration and study of the ores are those relating to secondary concentration. Close attention must be given to the wide variety of conditions controlling secondary concentration. In the Brazilian field, on the other hand, conditions determining secondary concentration are relatively unimportant in the practical study and exploration of the ores. The ores are in primary beds, and it becomes necessary then simply to follow primary beds and to

determine their length, breadth, thickness, and local variations. Impervious basins, topographic conditions, &c., which are so important in determining secondary concentration of ores, and which serve as guides for exploration in the Lake Superior region, are of less consequence in Brazil. However, some ores in Brazil have been enriched by secondary processes, and locally, therefore, the study of the conditions of secondary enrichment becomes necessary. Up to the present time, exploration based on possibilities of secondary enrichment have been practically *nil*, attention having been given only to the high-grade massive ores and jacutinga in primary beds, the former outcropping conspicuously at the surface, the latter frequently concealed by canga. The middle and lower slopes, under which secondary concentration may be effective, are likewise largely covered by the canga deposits, and the existence of possible ores or secondary enrichment in these localities, though unlikely, cannot be disproved until drilling is done in this district.

" Iron ores are the most widespread of metallic ores. All geological processes have some part in their concentration. As new districts are studied, these processes are found to have varying importance. The fact that the rich and abundant Lake Superior ores owe their formation largely to secondary concentration of sedimentary beds has led us to the conclusion that sedimentary beds of iron ore must necessarily be secondarily concentrated to make them high grade and valuable. Just as we are relaxing comfortably into the belief that this is well established, we find in the Brazilian field that the primary process of sedimentation is alone able to produce fully as rich ores as have been made by the primary and secondary processes combined in the Lake Superior region.

" The study of the origin of sedimentary iron ores has been directed towards their secondary alteration to

such an extent that little progress has been made in ascertaining precisely the topographic, climatic or other conditions controlling the deposition of sediments rich in iron. The proof that there are in Brazil beds of iron oxide running up to 2,000 ft. in thickness, containing 65 per cent. or more of metallic iron, which were deposited substantially in this form, brings us squarely against a problem of sedimentation which requires for its solution much more extensive knowledge of the factors which have influenced sedimentation of iron-bearing beds in their variable occurrence over the world."

GATHMANN'S THEORY DISPUTED.

In an article by Herr Th. Gathmann in the *Zeitschrift fur Praktische Geologie* (May, 1913), on the so-called itabirite ores of Minas Geraes, the writer cites evidence for, and attempts to prove that these ores are secondary surface deposits, formed by the leaching of silica from an iron oxide bearing quartzite for which the term itabirite has been adopted. As a result of three years spent in exploration work, both surface and underground, in various parts of the Minas Geraes iron ore field, Mr. E. C. Harder has gained a different impression of the nature of the itabirite ores from that held by Herr Gathmann. In his opinion, which is very clearly stated in the March, 1914, number of *Economic Geology*, practically all the ores except the surface blanket of " canga," or iron ore conglomerate, are metamorphosed forms of original sedimentary ore beds and lenses, and they were not formed from itabirite by the leaching of silica as Herr Gathmann maintains.

Mr. Harder gives a lengthy description of the various ores, and from practical experience on the field he comes to the conclusion that " itabirite and the associated iron ore are original sedimentary rocks, formed partly by mechanical and partly by chemical or perhaps biological

deposition. The association of limestone, quartzite and schist with itabirite, and of the latter with iron ore, always as lenses or interbedded layers, strongly suggests a similar origin for all of these formations. Such wholesale leaching of silica to great deposits, as would be necessary for the formation of these ores by secondary surface action seems improbable, especially when it is considered that what has happened to the ore has also happened to the interlayered itabirite and other associated rocks. The numerous outcrops of limestone in the district bear evidence that such extensive surface solution and decomposition are not widespread. It might be said that the localities where the ore occurs may be topographically and structurally favourable to surface action, but there are localities in which the same structural and topographical conditions prevail, yet where in one place ore is found to a depth of 35 metres or more, at another sandy itabirite occurs directly underneath the ' canga ' within a metre or two of the surface.

" The question as to whether the iron ores of Minas Geraes are the result of original deposition or of surface concentration," concludes Mr. Harder, " is one of great practical importance. If the ores are the result of surface weathering agencies, then they cannot be expected to go to any great depth, except, perhaps, along important water channels such as have been found to occur in some of the deposits of the Lake Superior district. If, on the other hand, they are the result of original deposition, then the depth to which they might continue is indefinite, and the changes to be expected are only such as would result from processes affecting original sedimentation. The facts seem to me clearly to prove the latter view."

THE PRINCIPAL IRON ORE DEPOSITS.

The principal iron ore deposits form part of the Serra do Espinhaço, the others being found in the Serras do Mar

e Mantiquiera. The rocks of the first range of mountains are constituted of schistose quartzites, micaceous schists and limestones, being known as the itacolumite series. These rocks appear to run successively into micaceous schists and schistose quartzites, which in turn pass into an almost pure hematite named itabirite. The base of the rock series is gneiss or granite, and on them the principal iron formation rests, interstratified between the schists and limestones. Owing to the faulted character of the country, the precise order in which the rocks occur are unknown, nor can their age be determined, though Dr. Derby is inclined to think that they may be assigned as Archean, pre-Cambrian or Lower Silurian. As manganese is so intimately associated with the iron formations, Dr. Derby is of opinion that they may be residual metamorphosed deposits of limestones which originally contained carbonate of iron. The second series of mountains consist of gneiss, with injected diorites and granites, and the deposits in them are, so far as known, exclusively magnetite, and of less importance than those already mentioned.

The ores found in the principal deposits have been divided into three classes—as massive hematite ores, micaceous iron schists and rubble or conglomerate ores. The massive hematite, which has often associated with it a small quantity of magnetic oxide of iron, constitutes the more important class from the economic point of view. It occurs in enormous beds, 30 to 50 yards in thickness, generally very much tilted up and out-cropping on the summits or along the sides of the mountains, where, owing to its excessive hardness, it has resisted erosion better than the enclosing rock. It generally contains from 66 to 70 per cent. metallic iron. The micaceous iron schist, or itabirite, consists of alternate bands of varying thickness of micaceous iron ore and quartz, both these minerals, and especially the quartz,

being often in a very friable condition, which accounts for its facility of weathering. The constituents of the schist sometimes enclose an ochreous mineral known as jacutinga, which often carries gold values. The itabirite is preferred to the massive hematite ore by the native ironworkers, because the micaceous character of the ore facilitates reduction in the small furnaces worked on the direct process. The rubble or conglomerate ore, the result of the weathering of the two other classes and more especially of the itabirite, is found in one or the other state according as it is anhydrous and pure or hydrated and mixed with argillaceous matter. The rubble ore is always found on the surface, in thickness varying between one and ten yards. Owing to natural concentration, this rubble constitutes a very rich ore, averaging 66 to 70 per cent. metallic iron, whilst the conglomerate portion, which from its very nature is hydrated and mixed with argillaceous matter, contains a very much lower percentage of iron, varying according to the intermixture of binding material. Where possible the native ironworkers use the pure rubble ore, and so dispense with the concentrating process necessary when the micaceous iron schist is used.

PRINCIPAL DEPOSITS COMPARED.

The outcrops of the principal deposits of Minas Geraes have so much in common, both as regards their position and the quality of the ore, that a detailed description of each of them would be of little interest. But Mr. Kilburn Scott, in his paper read before the Iron and Steel Institute on "The Iron Ores of Brazil," has very concisely compared a few of the characteristics of the Pico d'Itabira do Campo, the deposits of the Caraça and the Tapanhoacanga Mountain and the Pico d'Itabira do Matto Dentro. The latter, which is 75 miles from the Sabara Station of the Central Railway, has very much in common

with the Pico d'Itabira do Campo, and consists of an immense body of purest ore, which outcrops very strongly at an altitude of about 4,250 ft. above sea level. But unlike the other "Pico," where the stratum is vertical, this one has an inclination of about 30 degrees. The distance from the railway renders it of little present economic importance, but this disability will be removed by the extension of the Victoria to Minas Railway, which is now in course of construction.

Along the Caraça Mountain, which is one of the largest in the district, the iron ore deposit is more imposing and certainly more extensive than that of the Pico d'Itabira do Campo. The outcrop is nearly vertical, and the deposit, which extends almost without a break along the mountain for about 25 miles, as far as can be seen is about 50 yards in thickness. Mr. Henri Gorceix always considered this the largest iron ore deposit in the district, and he estimated the quantity of easily workable ore at some hundreds of millions of tons. The Tapanhoacanga Mountain, which runs parallel to that of Caraça, is covered for some miles with rubble and conglomerate ore, the result of the erosion of the Caraça deposit, and especially those parts of it that are essentially a micaceous iron schist.

But the most favourably situated body of iron ore in the State of Minas Geraes, and, indeed, in the whole of Brazil, is that of the Pico d'Itabira do Campo, which extends to within about 2½ miles of the Central Railway and some 1,640 ft. above it. The thickness of the deposit, which is tilted almost to the vertical, is somewhat difficult to determine, but it is probably more than 50 yards in width where the "Pico" proper rises 480 ft. above the mountain summit. All around this mass, huge boulders of ore exist in great profusion, and for some distance along the slope of the mountain there is the usual surface deposit of rubble or conglomerate ore.

The natural facilities for economical working on a large scale are very great, and in view of the enormous dimensions of the outcrop and purity of the ore, it is probable that large quantities of mineral could be excavated without the removal of any overburden to speak of, or appreciable rejection on the dump.

A CHAIN OF IRON ORE.

Mr. E. Levasseur, in his *State of Minas Geraes* (published in Paris, 1912), says that in addition to the iron deposits of varying degrees of vastness existing in this State, there is a chain of iron ore so enormous and extensive that the French engineer, Monlevade, who made a prolonged examination of the region, affirms that a single one of these deposits contained more iron than all the mountains of Europe put together. "All these incalculably immense deposits," writes Levasseur, "are found in the east and central portions of the State, and principally in the section of the Serra do Espinhaço, which forms the line between the basin of the Rio Doce and that of San Francisco. They extend for more than two degrees of latitude, with a width of more than one degree of longitude. From Barbacena to Grao Mogol, the most inexperienced eye sees everywhere the continuous outcrops of metal of high value. The traveller going over the region of Bello Horizonte (the capital of the State) is struck, at first sight, by the quantity of mineral furnished by the Serra do Curral and the Serra d'Itabira; further to the east, by the Serra do Caraça and a number of other mountains, stretching out beyond the line of vision and formed of almost pure iron. . . . The mineral of these deposits is generally very pure. The Pico d'Itabira do Campo, especially, is composed of a special mineral classed under its own name of itabirite iron. In this neighbourhood are also found immense deposits of hematite of 66 per cent. This hematite is analogous to the

minerals which have obtained the best output by the electro-metallurgical process, which is on the point of producing an incalculable revolution in the iron industry."

In all the accounts published of the mineral resources of Brazil, the magnitude of the Minas Geraes deposits, and especially of the district of Pico d'Itabira do Campo, and the outstanding purity of the itabirite iron is invariably insisted upon. Mr. Kilburn Scott, who emphasizes the favourable situation and natural facilities for economical working presented by the Itabira body of ore, writes: "Anyone travelling through what is known as the mining zone of the State of Minas Geraes cannot fail to be impressed by the immense deposits of iron ores which exist either as huge strata, generally very much tilted and forming the body of some of the extensive mountains, or as surface-layers of rubble or conglomerate ore, the result of the erosion of the stratified deposits, and which cover many square miles of the mountain slopes. I have examined the Lake Superior deposits, as well as extensive beds of ore in other places, and I am decidedly of opinion that the Brazilian deposits exceed, in a very appreciable degree, any I know, both as regards the quantity and quality of the ores, as well as the facility of mining. They, in fact, constitute, very probably, the most important known iron deposits in the world. The purity of the ores is especially remarkable, phosphorous only existing in a small quantity in the superficial rubble or conglomerate ore, being to all intents and purposes absent from the original ore deposits."

"A REAL MOUNTAIN OF IRON."

Mr. W. H. Herdsman, of Messrs. E. Riley & Co., whose study of the iron ore districts of Brazil left him much impressed by the character and extent of the immense deposits of Minas Geraes, writes respecting the outcrop of Itabira do Campo as follows: "Although one

hears frequently of mines and deposits which are described as being 'mountains of iron,' I have never, in my twenty-five years' experience, until I visited Itabira, found one which even remotely justified the title; the Pico d'Itabira is, however, a real mountain of iron, and doubly remarkable in the uniform purity of the mineral, for from the moment of arrival on the iron ore area I did not find one single fragment of stone which was not mineral, nor one single piece of mineral which was not of the same pure and rich quality as is evidently the whole of the gigantic body of ore. I use the word 'gigantic' advisedly, for there can be little doubt that not less than ten millions of tons of the purest ore known is found outcropping here at a single point, and when one remembers that a similar outcrop is found some 95 miles distant, and that other lodes and ore bodies are found at numerous intervening places, while the whole adjoining country is covered with iron ore, 'canga,' in every direction, the immensity of the Brazilian ore deposits becomes very evident."

Samples taken by Mr. Herdsman from the Pico d'Itabira do Campo deposit (massive hematite) and analysed in Messrs. E. Riley & Co.'s laboratory, gave the following results:—

Silica	0·37	per cent.
Peroxide of iron	98·98	,,
Alumina	traces.	
Oxide of manganese	0·20	,,
Lime	0·18	,,
Manganese	0·18	,,
Phosphoric acid	0·023	,,
Arsenic acid	nil.	
Sulphur	0·007	,,
Oxide of copper	nil.	
Carbonic acid	traces.	
Combined water	0·10	,,
Moisture	0·12	,,
	100·160	,,

ESTIMATES OF TONNAGE.

From his protracted study of the iron ore field of the eastern central part of Minas Geraes, Dr. Derby concludes that any attempts to estimate the amount of ore in the district must be extremely fallacious. Practical iron men and geologists who have visited parts of the district (no one has an intimate knowledge of it as a whole) hesitate to pronounce impossible estimates that, at first sight, would appear preposterous. Dr. Derby refers to Professor Gorceix's original estimate of five billion tons, but he quotes a further statement made by Gorceix in 1881, in which he declared: "I have estimated at five billion tons the iron ore that Minas Geraes might furnish, and I fancy that I should not be exaggerating if I should double this estimate."

Dr. Derby, striving as he always did to be well within the mark, found it difficult to reconcile his conservative estimates with what be believed would be found to be the actual production of the region, and every expert authority surpasses him in calculating the iron content of the district.

"Estimates of tonnage for the region as a whole," write Messrs. Leith & Harder, "would be premature with the present state of knowledge, but it is certain that the estimate of Dr. Derby (made for the International Geological Congress held in Stockholm, 1910) of two billion tons for the district is conservative. Of the high-grade massive hematite and jacutinga, ranging from 63 to 69 per cent. of iron, the tonnage is probably not far short of the total reserve of available ores in the Lake Superior region to-day (1911). Individual deposits contain several hundreds of millions of tons."

Professor Richard Penrose, the well-known economic geologist who rode with Dr. Derby over a small part of the Minas Geraes district, mainly included in a large property for which the owner's estimate was of

" hundreds of millions of tons," writes in a private letter to Dr. Derby : " I do not know just what the extent of their property is, but though one cannot see such quantities of ore actually blocked out, yet I would not consider such a statement as impossible for future realisation in the regions you and I visited last year. I think such quantities might be produced. Of course, where the iron alternates in thin lamellæ with the siliceous layers, it is undesirable as an ore, because it is too siliceous. If, however, we exclude such material and count only the larger bodies of pure ore that occasionally occur in it, such as the iron ore peak (Pico d'Itabira do Campo) which we visited, and then consider the area of country over which the iron formation extends, the possible tonnage is immense."

CUBIC CONTENTS.

The cubic contents of the limited number of the ore bodies have been estimated by competent observers on the basis of actual approximate measurements of their outcrops, but, for the most part, this has been done by private parties and the information is not available. The examples and estimates for nine of the deposits, made by Dr. Gonzaga de Campos of the Serviço Geologico of Brazil, which are believed to be as reliable as can at present be made, are as follows :—

Gaya	72,000,000	cubic metres.
Conceiçao	80,000,000	,,
Esmeril	19,000,000	,,
Caué (Itabira Peak) ..	33,000,000	,,
Pitanguy	14,000,000	,,
Sao Luiz	8,000,000	,,
Peak of Itabira do Campo	8,000,000	,,
Rio de Peixe	10,000,000	,,
Cocaes	3,000,000	,,
	247,000,000	,,

Taking the mean specific gravity of these ores as 4, this volume represents 988,000,000 tons. The above list includes several of the largest known deposits, so that the contents of the others cannot be estimated on a proportional basis, but it seems quite safe to assume for them at least an equal volume, which would double the above figure. It will be noted that in these estimates no account is taken of the presumed underground extension of the visible ore bodies.

No attempt has been made by Dr. Derby to estimate the volume of the rubble ore deposits, which are known to be both numerous and extensive throughout the district. So far as he has learned, only one such deposit has been actually measured by competent mining engineers, and this is said to carry 20,800,000 tons of rubble ore, easy for stoping, carrying 50 per cent. iron. From what is known of the district, Dr. Derby considers it quite safe to assume that there are some scores of deposits of equal importance and that, in the aggregate, the volume of rubble ore is at least equal to that of the quarry ore.

As regards the "canga," Dr. de Campos estimates roughly that it covers about 10 per cent. of the area occupied by the iron-bearing formation, which is about 5,700 square kilometres. For the purpose of calculation, however, he takes 5 per cent., with a mean thickness of two metres, which gives 570,000,000 cubic metres, which, calculated with the mean specific gravity of 3, gives 1,710,000,000 tons of ore, whose mean iron contents will probably oscillate in the neighbourhood of 50 per cent.

"THE TIMES" ON THE ORE DEPOSITS.

On the subject of the magnitude of these iron deposits the *Times* of February 27th, 1912, contained the following particulars: "During recent years a number of eminent mining engineers from the United States and Europe

have visited Brazil in order to reconnoitre, study and report on these vast ore masses which are now considered to be the richest and most extensive in the world. The part of the field in the State of Minas Geraes which is being mapped out embraces an area of 5,700 square kilometres, covered with the iron-bearing formation, which is known to extend to the north-eastward and south-eastward, giving a total area of more than double this figure. What the total contents of this iron-bearing district may be it is extremely difficult to compute. Practical iron-mine geologists who have visited parts of the region give various estimates that amount to billions of tons. The estimates made by Dr. de Campos of nine of the principal outcrops of quarry ore will give some approximate idea of what the figures will amount to when the district becomes better known. . . . The quality of the ores is high and uniform, and rivals the best found in Sweden and other parts of the world."

In *Twentieth Century Impressions of Brazil* the contents of the iron mines already exploited in the country are estimated to exceed six billion tons, while Mr. J. C. Oakenfull, in his *Brazil in* 1912, states that: " The whole of the fifty-two outcrops surveyed by the Government Mining Engineers are reckoned to contain not less than twelve billion tons of ore of the highest possible grade. This is in one district only—Central Minas Geraes."

Signor Arrajado R. Lisboa, the well-known Mining Engineer of Rio de Janeiro, writing in the *Engineering and Mining Journal* (New York, 1907), says: " Iron deposits are abundant in Brazil, and there is no doubt that these deposits constitute one of the greatest iron ore reserves in the whole world. For lack of mineral fuel the iron industry is not developed. . . . When the manufacture of iron by electricity becomes an economic reality, no country in the world will offer more advantageous

conditions for the development of the industry: not only because of the abundance and superior quality of the ores, but also because of the available sources of hydraulic power."

THE IRON-ORE DEPOSITS: A REVELATION.

In a paper on "The Iron Ore Industry in Brazil," read by Mr. E. C. Harder at a Pittsburg meeting of the American Institute of Mining Engineers in October, 1914, the well-known mining engineer presented some facts and figures which were regarded in the United States as "something of a revelation to those who know little of the vast mineral resources of the largest of the South American Republics." Mr. Harder showed that the widespread and general attention that had been attracted to the Brazilian iron-ore deposits in recent years had been mainly due to the quantity and richness of the available ore in contrast to the ever-decreasing grade of ores shipped from many of the large producing iron-ore districts of the world. "The general average grade of iron ores shipped from the Lake Superior district," he explained, "has decreased to approximately 50 per cent. natural, in recent years. The Rubio ore, of Bilbao, Spain, in 1890, average 55·5 per cent. metallic iron, dried; in 1902, 52·8 per cent.; while at the present time a large proportion of the ores shipped from Bilbao are obtained by working the old dumps. In Northern Sweden, where large magnetic deposits have only in recent years been extensively developed, selected mining is even now necessary in order to obtain high-grade Bessemer ores. During the last two years the iron ores of Chili have attracted much attention on account of the activities of the Bethlehem Steel Company and others in the Chilian iron-ore district. Many of these ores are of good grade, yielding 67 and even 68 per cent. metallic iron, but, judging from the writer's observations in this

region, a large proportion of them will be found to be of non-Bessemer grade.

" The most important variety of iron ore in Brazil is hard, dense to specular hematite, occurring in Minas Geraes. A large number (89) of analyses of this type of ore have been averaged, giving the following composition :—

	Per cent.
Iron	69·65
Phosphorous	·0125
Silica	·24
Combined H_2O. ..	·38

" In few places in the world has iron ore been found in marketable quantities which even approaches this in grade, while in Brazil several hundred millions of tons of such ore are in sight, occurring practically on the surface, while, besides this rich ore there is an almost incredible amount of lower grade ores, i.e., ores of 60 per cent. metallic iron and over. It may be found impracticable when mining operations commence, to mine exclusively the high-grade ores, and that admixture of other ores will somewhat lower the general quality of marketable material ; still, it is safe to say that Brazil will be able to furnish for many years ores of Bessemer quality, which will average more than 68 per cent. metallic iron."

THE ITABIRA DO MATTO DENTRO MINES.

The estate comprising Conceiçao, Caué and Sta. Anna, which forms the richest hematite iron ore properties in the district of Itabira do Matto Dentro, and one of the most important iron propositions in the State of Minas Geraes, was famous during Colonial days as a gold area, and was extensively worked during the latter part of the seventeenth and the beginning of the eighteenth centuries. The old and now completely ruined

workings show that operations were conducted on a very extensive scale, but apparently to no very great depth owing to the water difficulties. Between 1869 and 1873 an attempt was made by the General Brazilian Mining Company to reopen and operate the mines, but the enterprise was unsuccessful. The failure is said to have been due to bad management, immense transport difficulties—the estate was at that time 400 miles from the railway—and the want of adequate cheap native labour for the proper development of the workings. From the year 1873 the Caué Mine—evidently the most important of the three—was profitably worked for about five years by a Brazilian Syndicate, who are known to have extracted gold to the value of considerably over £100,000. During the process they utterly ruined the workings.

The Caué and Sta. Anna properties which adjoin each other, and the Conceiçao, which lies some six or eight kilometres distant from them, are located in the undulating country to the east of a high range of mountains called the Serra do Espinhaço. The general rock formation common to the three properties consists almost entirely of ferriferous schists. The direction of this strata varies somewhat in the different areas, though in each it runs with extreme regularity and is usually seen to dip at a high angle from the horizontal. The ore deposits are of a bedded type and are found intercalated between the ferriferous schists and run parallel to them both in dip and in strike. In his report upon the properties, Mr. William Selkirk, F.G.S., says: "This is a district which contains a rock formation exceedingly favourable to the existence of large iron ore deposits, and which covers not only the properties described, but also the area between the properties, and very likely a much larger area beyond these limits. It has already been proved that this rock formation contains several large deposits of iron ore of very exceptional purity, and I do not

exaggerate when I say that there is every likelihood and every reason to believe that prospecting in the unknown portions of this property would lead to other and equally valuable discoveries. This view is strengthened by the fact that after leaving the properties I noticed, on taking a bird's-eye view of the Conceiçao property at a distance of two or three miles, what appeared to be an exceedingly prominent outcrop of iron ore, extending over a considerable length. This was in a portion of the property quite unknown, and with a good deal of jungle all round it."

QUALITY OF THE MATTO DENTRO ORE.

The reports made upon these properties show that all the experts are agreed as to the phenomenal richness of the vast quantity of mineral they contain. Messrs. Pattison & Stead state that this ore " is a specular hematite of exceptional purity, admirably suited for all classes of iron and steel making." Mr. T. W. Hogg, of Newburn Steel Works, Newcastle-on-Tyne, declares it to be an exceptionally good ore for steel-making purposes. " This is the purest sample of ore I have ever examined," he says, " and if it can be supplied in cargoes similar to the above, it will be a valuable help to pig-iron makers, and nothing better can be got for open hearth steel-making, either acid or basic." Mr. Selkirk, who was particularly careful to select his samples so as to make them as representative as possible, asserts that the ore is almost chemically pure. " The quality of the ore," he reports, " is without exception the finest I have ever seen in the whole of my experience, and finer than any I have ever heard of." Mr. Thomas A. Down, M.Inst.M.M., writes that from the plans submitted it has been ascertained that there is in sight " 95 million tons of 68 per cent. iron ore, practically pure hematite, particularly free from phosphorous and in every other

respect highly suitable for the manufacture of steel." Senhor Gonzaga de Campos, who visited the properties in 1909, states that "as regards the percentage of metallic iron, and particularly the purity of the ore, we believe it is unrivalled in the world."

This unanimity with regard to the quality of the ore of Itabira do Matto Dentro is also observable in estimating the vastness of the deposits. Mr. Selkirk reckons the quantities of proved ore on the Conceiçao property at 9½ million tons, with a probable additional quantity of 16½ million tons, available at a depth to which the deposits can be worked open cast, without going into the hypothetical calculation of ore below the exposed areas. On Caué and Sta. Anna properties Mr. Selkirk states that there is a quantity of some 14 million tons of ore actually exposed and ready to be mined. In addition to this there is a further quantity of about 12 million tons, which, though not actually visible and measurable, he has no doubt exists. In conclusion, Mr. Selkirk remarks: "There is a quantity of between 60 and 70 million tons of ore, which I am sure can be obtained at a cheap rate from the various properties and from that portion of them only which is at present known." Senhor de Campos, whose figures are probably based on topographical contours, estimates the ore on Caué property at 130 million (metric) tons and on Conceiçao as 400 million (metric) tons. In his report, dated December 31st, 1910, Mr. T. A. Down makes the following statements: "The following estimates are carefully calculated from correctly made plans: Caué—Sta. Anna deposit, 30 million tons ore of 69·5 per cent. iron, or by taking in a greater perimeter, 50 million tons ore of 68 per cent. iron. Conceiçao deposit: 25 million tons ore of 69·5 per cent. iron, or by taking in a greater perimeter, 45 million tons ore of 68 per cent. iron. Totals, 55 million tons ore of 69·5 per cent. iron, or 95

million tons ore of 68 per cent. iron." Mr. Down expresses his conviction, after giving the matter careful consideration on the spot, that within four years from beginning to export ore, the mine could be placed in a position to produce for shipment at least two million tons annually.

In another part of his report Mr. Down declares that Itabira do Matto Dentro is undoubtedly destined to be one of the greatest iron-producing centres in the world. " The gold mining business will, of course, be secondary to that of the iron," he writes, " but none the less it possesses immense possibilities, and once the iron mining is thoroughly established, you will be able to take advantage of the ample and cheap native power and the facilities to be obtained from an up-to-date engineering establishment to very economically explore the gold workings in depth ; and judging from what I have been able to gather from the past history of the mines, from the geological and surface indications, and from what I have been able to see of the old workings, I am strongly inclined to think results would amply justify the necessary capital outlay. When the proper time comes it will be quite practicable with a modest capital to open out the mines much below the level of the deepest workings reached by the old workers by means of tunnels and vertical shafts."

A SANTA BARBARA IRON PROPERTY.

Another important iron ore estate possessing enormous possibilities consists of three adjoining properties situated on the Serra Seana, some 15 miles north of the town of Santa Barbara, and about 25 miles south of Itabira do Matto Dentro. Of the three properties, the Morro Agudo, with an area of 900 acres, rises to a peak some 4,265 ft. above sea level, which forms a conspicuous landmark in the region. The Agua Limpa area of 1,200

acres attains a height of 4,100 ft., and the intermediate property lies between these two hills and is situated more or less in the intervening valley. The Morro Agudo peak is not a capping but a solid mass of iron ore, and the hundreds of feet of cliffs which rise to the summit on three sides show the foliation and solidity of the ore body. Descending from the peak towards the Agua Limpa, a path has been cleared for nearly 2,000 ft., again exposing the solid mass of iron ore. At the end of this path the ore body dips and is lost sight of under a great thickness of boulders of iron ore, clay, &c. It emerges in parts of the middle of the property and is seen again ascending the Agua Limpa hill. In its ascent a solid mass of iron ore is visible for hundreds of feet in length and breadth, the top of the hill forming a kind of plateau.

As a description of the geology of the estate and the mode of occurrence of the ore deposits, Mr. E. A. Mannheim, who visited and reported upon the properties in November, 1912, quotes from the report of Dr. Derby, which is reproduced here on page 44, under the heading of "The Iron Ore Districts of Minas Geraes." Mr. Mannheim adds: "The iron ores of Morro Agudo and Agua Limpa are of the best quality; they are, in fact, practically pure hematite identical with the Itabira deposits. This hematite is mostly specular iron, steel grey in colour, with a high lustre. The numerous samples taken and analysed gave an average result of about 68 per cent. iron, corresponding to formula $Fe_2 O_3$. About 260 ft. below the peak the hill measures at least 2,625 ft. in circumference, exposing a solid mass of iron ore. Descending the hill south the iron ore can be followed for at least 2,000 ft. before it dips underground. As exposed, this mass could be quarried without any underground mining operations, and I estimate its tonnage to be at least 20,000,000 tons.

"On the Agua Limpa I estimate the probable iron ore to be obtained by quarrying to exceed that of Morro Agua, and the tonnage to be not less than 30,000,000 tons.

"On the middle property it would be difficult to estimate the probable iron ore to be mined. The iron in that part of the property only outcrops in places and to no great extent, but some prospecting work would, no doubt, prove extensive ore deposits.

"With regard to persistency in depth, and additional quantities of ore, I have no reason to doubt that the ore bodies will continue to a good depth, especially considering the great length of outcropping extending from the feet of these mountains to the summit of over 1,640 ft. (above the River Sao Francisco, situated at the foot of the Agua Limpa Mountain). The strata is very regular, and no faults are visible. . .

"The iron forming these hills is generally exposed on two or three sides, and an examination of the faces rising to great heights leaves no doubt that the iron is in solid bedded deposits. I might mention that on the Agua Limpa properties the owners for generations have worked the ore at the base of the hills. They have smelted the ore with ordinary charcoal, and made from it horseshoes, shears, ploughs, and many other iron implements required in the district."

The power to be derived from the utilisation of the various water rights on the properties can be brought up to a total available power equal to about 19,000 h.p., while ample wood fuel is obtainable and the labour problem in this district presents no difficulty.

"In conclusion," Mr. Mannheim says, "it is my opinion that the quality and quantity of these iron deposits are such as to warrant their exploitation on a large scale for exportation, and that this should yield a handsome profit. These deposits, and those of the Itabira Company, are the best I know in this district,

and contain both high-grade ore and large tonnage. The working of these large deposits is now made practicable by the fact that . . . . you have a railway concession from the mines to a deep-water port, and of a length considerably less than that of the Itabira Company, or of any other railway which might be built from the mines to the coast. The exploitation of this railway, traversing as it does much high-class agricultural land, should in itself prove also a remunerative investment."

DIAMONDS IN BRAZIL.

Tradition has it that diamonds were first discovered in Brazil in the gold washings of Minas Geraes in 1670, and that the miners, ignorant of their value, collected them as curiosities and used them as counters in their games of chance. It is certain, however, that diamonds, identified as such, were not known to exist in the country earlier than 1721, when the discovery was made in the Morrinhos River, near Tejuco, on an area which has since become famous under the name of Diamantina. The State of Bahia was next found to contain diamonds, and the gems have since been located in various localities in the States of Goyaz, Matto Grosso, Sao Paulo, and Parana, but the diamond industry until 1912 was practically confined to Minas Geraes and Bahia, the fields of the latter State being the more important on account of the occurrence of carbonates with the diamonds. In the early part of 1912 it was reported that a new field, covering a large area and rich in the finest quality of stones, had been discovered on the Garzas River, in the State of Goyaz. It is claimed that the gems on this field are to be found almost immediately below the surface, and 400 miners are said to be working there.

With the discovery of 1721, all freemen, except those engaged in the supervision of the slaves and the protection of the convoys, were banished from the region, and

the industry was so hampered by the rigorous conditions imposed by the Portuguese Government, that after the first excitement had subsided, the industry languished until the termination of the Colonial period. But no fewer than 40,000 men were employed in Minas Geraes in 1732, and from that year until 1771 the diamond export of Brazil amounted to 1,666,569 carats, valued at £3,600,000. The Declaration of Independence of 1822 was followed by relief from the worst of the Colonial taxation, and the condition of the industry rapidly improved. But by this time Diamantina had lost much of its popularity, and when, in 1832, the diamond fields were thrown open, the output showed a considerable falling off. The system of slave labour was then in force in Brazil (and remained so until May, 1888), and the majority of the slaves employed on the diamond fields proved themselves expert thieves. In order to inculcate a sense of honesty, rewards were given to successful workers, and the finder of a stone of 17½ carats or more received his freedom. Despite such inducements to adopt what usage has proclaimed the best policy, and a strict supervision of the operations, much successful smuggling was accomplished, and it is said that the muleteers travelling between the mines and the capital found the barrels of their matchlocks very useful receptacles for the stolen gems.

But in the face of the many difficulties with which the industry had to contend, in the way of dishonesty, lack of transport facilities and Government protection, and the burden of exacting tolls, no less than a million carats had been taken from the River Cyuaba, and a quarter of a million carats from the Paranahyba and Claro Rivers, up to 1850, and during the century and a half which elapsed between the first recorded find of the precious stones and 1871, Brazil held the world-record in the production of diamonds. The impetus given to the

industry by the general prosperity of the opening decade of the present century, is indicated by the production of the State of Bahia of 154,307 carats in 1906, 189,949 carats in 1907, and 298,046 carats in 1908. The estimated entire output of the Bahia fields to the end of the latter year was 12,351,576 carats, and the diamond production of Brazil from 1721 to 1812 is calculated at the total value of £12,000,000.

THE DIAMANTINA FIELD.

The City of Diamantina is situated 800 kilometres north-west of Rio de Janeiro, and 250 miles from the coast in a direct line. The Central Railway to Curvello approaches within about three days' mule journey of the city, and is being extended to reach the field. The district, which is from 3,500 to 5,700 ft. above sea-level, contains the head waters of the Jequitinhonha, Arassuchy and Doce Rivers, and is full of deep ravines, worn by a multitude of streams. In the small hollowed-out plateaux of the region, the ground is damp and spongy, and is studded with clumps of high grass. The outer scarps are very precipitous, and the streams, in the summer season, attain a velocity and volume that excavates pot-holes in their beds in which diamonds are most likely to be found.

The diamond-bearing quartzites of Brazil consist of 90 per cent. silica and 2 per cent. of oxides of iron and aluminium. The gems are found in a sort of blue clay deposit, in beds a few feet in thickness, inter-stratified through a great mass of multi-coloured clays, stained by oxides and organic matter. The surrounding rock consists of sandstones and schists. In the Minas Geraes fields, as elsewhere, the pot-holes and deep pools are, of course, the richest, but frequently an immense amount of debris from ancient workings has been deposited on

the diamond-bearing cascalho, or gravels, in the lower parts of the rivers.

The Abaeté River, some 170 miles long and from 200 to 500 ft. wide, runs between the Serras Canastra and Matta da Corda. The cascalho contains jaspers, garnets, gold, platinum, osmium, iridium, and some thirty other minerals, more or less rare. The Somno has a total length of 140 miles, and flows into the Paracatu, and its gravels consist of jaspers, black tourmalines, limonite, rutile, kyanite, martite, and gold, and an abundance of small garnets. The whole of the rivers in this district, and the small plateaux between, are diamondiferous, and contain gold in connection in almost every case.

Bagagem (now Estrella do Sul), eleven leagues from Araguary, the terminus of the Mogyana Railway in Sao Paulo, is situated in Minas Geraes on the River Bagagem, a tributary of the River Paranahyba. Here the Dresden and the Estrella do Sul diamonds were found. Agua Suja is some twelve miles from Bagagem. The geology of the district consists of schists with granite dykes, crossed by quartz veins, overlaid by level beds of sandstone, having layers of trap intercalated. In conjunction with the diamonds here are staurolite, rutile, anatase, tourmaline, phosphates, mica, and garnets. Although the Bagagem and Agua Suja workings were neglected for many years, the discovery of a very fine diamond in 1910 at the former place, revived local interest, and many men are again engaged in searching for the elusive gems in these districts.

THE BAHIA DIAMOND FIELDS.

The small diamond-bearing deposits of Parana, Paranapanema and Rio Verde in Sao Paulo are a continuation of the Minas Geraes fields. In Parana, in sandstone quartzites, the Rivers Tipagy, Pitangru, Yapo, &c., contain diamonds, especially in pot-holes, the best

results being obtained where the conglomerate is formed by a hard-blue cement, somewhat similar to the blue ground in South Africa. The gems are small, irregularly shaped, but of fine quality. The largest stone found was worth £60.

The diamond region in the State of Bahia is situated some 375 miles, in a straight line, to the north of Diamantina. The principal fields in the district of Lençoes have been worked in a spasmodic and wasteful fashion by both native and foreign diggers for upwards of half a century. The world's supply of carbon is entirely derived from this district, which forms a plateau at an elevation of between 2,000 and 3,000 ft., and contains the headwaters of the Paraguassa River and its tributaries, and of some arms of the Itapicaru, which rise on the northern reaches of the tableland. The topography of the country is generally one of square flat-topped terraces, through which the rivers flow in cañons often hundreds of feet deep between perpendicular walls. The diamond-bearing rocks, which are locally known as the Lavras series. They have a total thickness of 2,000 ft. and are supposed to belong to the same age and formation as the carboniferous rocks of the country. The principal diamond-bearing rock deposits are more or less folded, the folds in some places being extremely gentle and in others greatly distorted, especially in the mountains west of Gruna, where the beds are very greatly contorted and faulted and can, therefore, be easily recognised. The diamond-bearing rocks are mainly pinkish quartzite, sandstones and conglomerates, the pink colour appearing to be characteristic of the deposits everywhere, except in exposed situations where the surface has been much weathered. Dr. Branner, who has the credit of being the first to study the geological sequence of the rocks of Central Bahia, says that the pink quartzites are the main beds, and the streams rise and flow through

these rocks everywhere in the Bahia field. The theory is that (according to geological evidence) the gems come from these lavras. It must be noted that no eruptive rocks occur in direct connection with the lavras, and therefore the diamond cannot be derived from the former. There is, however, a remote possibility of their having originated in peridotites of the old crystalline series, and finding their way into their present matrix after several geological periods, favouring the hypothesis that the latter is their original place of creation.

The diamonds and carbonates occur in alluvial deposits, on a bedrock of micaceous sandstone, which is probably identical with the italcolumite of Minas Geraes and Diamantina. Numerous quartz veins (generally small in length and width) traverse the formation in all directions. The cascalho consist of itacolumite sand and fragments, quartz in all its varieties, and accessory to the richer parts are zircon, tourmaline, rutile, ciassiterite, garnet, magnetite, and other oxides of ron. The cascalho forms three distinct classes—the primary beds on the mountain plateaux, the deposits on river terraces, and the river gravel from the bottom of the streams to high-water level. The second and third classes are the natural products of the first. The process of concentration explains the unevenness of the distribution of the diamonds and carbons in the deposits in the river terraces and the river gravels. The places that naturally yield the most are small basins on the bedrock, boulders and above river bars, where both the diamonds and cascalho are river worn. In the exploitation of the primary beds on the mountain plateaux, the prospector is set a more difficult task, since he has practically nothing to guide him in his researches. As a rule it is the disclosure of a gem thrown up by a man in the making of a water catchment, or a foundation for a hut, that sets him digging for diamonds, for

although the beds are very patchy, the occurrence of a single diamond is regarded as a fairly reliable indication that a cluster of stones may be looked for in its immediate neighbourhood.

The areas on the Bahia fields that have been most extensively worked are the river sides between high and low-water level—which have been washed and re-washed but never appear to fail to reward the prospector—and the river terraces, and although all the work has been clumsily and wastefully laid out, the workings are by no means exhausted. The river bottoms are practically virgin ground. Diving and a partial diversion of the course of the river have been resorted to, and occasionally, when the waters are very low, men will wade among the boulders and delve for the gravel which is brought to shore and panned. Although these desultory labours enable the miners to make a living and frequently crown their efforts with lucky finds, the quantity of wealth won in this fashion can only represent an infinitesimal proportion of that which must exist. In the same casual manner, ground sluicing is practised, the riffles being formed of stone on the bedrock, and the resulting concentrates are panned and repanned until the diggers have assured themselves that they have extracted the last stone. But it not infrequently happens that another party will subsequently turn their attention to these accumulated and worked-out heaps, and recover from them quite as much as that won by the first workers. The diamond easily escapes detection even in the most skilfully manipulated pan, and the fact that the second washing of a profitable patch invariably recompenses the labour involved, has led the digger to the conclusion that it is just as advantageous to re-work old ground as to open up new. Small paddocks are consequently exploited until, in many cases, their faces fall in and their tailings bury the neighbouring ground, while

heavy rains occasionally flood their ditches and wash away both sluice and paddock. But the wandering digger of Brazil is either a philosopher or a very foolish fellow, and no sequence of "staggerers" appears to disturb his serenity. When his luck is out he subsists upon beans; when good fortune sends him a substantial find, he luxuriates until his last coin is spent, and then returns to his diet of beans.

The miners use the following simple tools: a batea (or pan) of hard wood, in which the gravel is washed; and a carimbé, similar to the batea, but smaller, which is used to carry earth or gravel to a distance when water is not available on the spot. The other instruments comprise a crowbar, a scraper or hoe, and a scoop for clearing out holes, together with a hammer to break up the masses of conglomerate. The miners work only in the dry season, three or four together in line, the first with the largest batea and the last one with a small pan, sifting the finest gravel and sand, whilst women go through the débris to pick out the stones which may have been missed.

Storekeepers sometimes make advances to the diggers and supply them with provisions, tools and other necessaries. Others buy claims and secure perhaps 25 per cent. for allowing more impecunious miners to do the rough work. They take good care, however, to wash the pay-dirt themselves, or to entrust this task to those in whose good faith they have confidence. Travelling merchants buy up the stones here and there, but most of the trade is done in Bahia. The bulk of the gems go to France, Germany and the United States.

Until about twenty years ago the carbonates were entirely disregarded by the diggers, and there existed a distinct danger that it would either become lost or prohibitive in price, not so much owing to the exhaustion of the deposit, but as the result of the slovenly and unskilful method of working the limited extent of ground

in which it is found. A large proportion of these discarded carbonates have since been recovered from sluice-head heaps of the larger and more systematic workings, dating back to the old slave days. Some of these workings have brought water from considerable distances, and have denuded large areas of plateau terrace ground.

METHODS OF WINNING DIAMONDS.

By making watercourses, derived from higher levels, the ground above these workings could be economically and successfully treated after the same manner, but the problem of working the river beds presents a more difficult proposition. Experts who have studied the problem appear to be agreed that diving operations can only be a partial success, since it can only be employed in pools, most of which have a very deep overburden of barren sand. Moreover, the process could only be intermittent in its operations, as the rains swell even these pools into raging torrents. Dredging is impracticable, as the precious cascalho exists only in the crevices of the river bed, which consists of huge boulders, rifts and caverns, and as the true cascalho is practically a cemented conglomerate, the application of the centrifugal pump offers no full promise of success. It must also be remembered in this regard, that the repeated blasting operations, which the constant shifting of the pumping-station would render necessary, would, in addition to entailing great expense, probably defeat the object of its adaptors by carrying the gems downstream. Any titanic proposal for the diversion of the rivers from the course of their deep, rock-bound cañons would be simply impossible of realisation.

Mr. H. L. Lawrence, who studied this problem on the spot, and thoroughly examined all the suggested solutions previously devised, came to the conclusion

(published in *The Mining Journal* in 1902) that the most practical way of attacking these rivers is as follows: "Divide the rivers and creeks into two channels, keeping one channel dry for working purposes, while the other channel carries off the water. This can be effected by the construction of a solid and strong dam at suitable points, i.e., at the islands which are always composed of massive rock of harder quality than the surrounding parts. These islands occur at frequent intervals. During times of flood they may be partially or altogether submerged. There are many situated about the centre of the streams, and those would naturally be selected for the purpose in question. From these dams a fairly water-tight wall must be carried right down the centre of the river. The natives are marvellously expert in building this sort of wall, which, it must be remembered, will, if properly located, have no pressure of current to withstand. The river boulders bound with the scrub and turf of the banks form the material to hand. It is very seldom indeed that the water rises above 13 ft. in height, so that wall and dam never need be above 15 ft. high. It is not necessary that the wall be completed before work commences, so long as it is constructed to a point sufficiently far ahead of the workmen to keep backwater from interfering with their operations. The river bed being once dry, the smaller boulders can be rolled away, and the bigger ones broken up or blasted. The cascalho must then be carefully scraped and washed out of all crevices, sluiced, panned, or treated as circumstances require. The quantity of gravel is hardly ever great. It is the very fact of these river bottoms being rock which has suggested the method here proposed. As soon as one side has been worked out, the first dam is demolished and another one built opposite to the place where it stood, in order to protect the unworked channel from the water which is turned into the exhausted part.

The frequent pools and falls which are formed by bars can be drained by the judicious use of dynamite either by tunnelling or cutting. The main object is to get a dry spot to work in, and this can only be practically effected by dividing the streams into two courses. The expense of this process under a clever engineer would be very low. I estimate the cost at not more than 10/- a cubic yard for strong cemented dam, and 1/- for a cubic yard of the dividing wall. Of course, there are other expenses necessarily connected with an enterprise of this sort."

The new law of the State of Bahia makes it obligatory upon proprietors of mineral lands either to work them or to submit to Government arbitration with regard to their sale. No licence is required to prospect with movable plant, and concessions may be readily obtained on navigable rivers, in reaches up to 50 kilometres in length. All diamond mines being the property of the State, no question can arise as to ownership. A licence for placer work costs a few milreis only. According to the British Consul at Bahia, the new regulations are well calculated to encourage exploitation of this, the richest zone in Brazil. The laws seem to have been based on the best features of those in force elsewhere. The taxes payable are from ½ to 10 per cent. In the case of monazitic sands, they are very heavy, but the profits afford sufficient recompense for the impost. To sum up, most of the abandoned properties were discarded for want of sufficient capital, or failed by reason of bad management. Legislation has been effected to protect prospectors and to guarantee to them the result of their labours. Registration and survey is compulsory, and no one can now pretend to ownership of a claim who is not possessed of properly stamped documents.

Although many rivers in the State of Goyaz are known to be diamondiferous, no systematic exploration of them has been made. In the early part of 1911, a prospector

came into the capital of the State with over 300 fine stones found in the Rio Graça, a tributary of the Araguaya.

In Matto Grosso, the principal seat of the diamond mining is the River Coxipo Mirim. The depth of the cascalho varies, but the maximum is about 14 ft., and is comprised of jaspers, amethysts and chalcedonies, rose zircons, anatase, almandine garnets, white topazes, sphenes, native silver, &c. The diamonds are small, the largest found being 5 carats. The form is usually dodecahedron with well curved faces. The surrounding formation is schists and quartzites. No carbonates or boart is found.

FAMOUS BRAZILIAN DIAMONDS.

Two diamonds produced by Brazil have become historic under the names of the Estrella do Sul and the Diamond of Dresden, both of which are now owned by an Indian prince. Both were found in the alluvial workings of the River Bagagem. The Estrella do Sul, discovered in 1853, weighed in the rough 255 carats and 125 carats cut, and the Dresden Diamond weighed 117½ carats uncut and 63½ carats cut. In 1910 a third gem was discovered, weighing 175 carats, which has been named the Estrella de Minas. Dr. Derby, writing in the *American Journal of Science* (September, 1910), advances the theory that these three diamonds were of the same original form, i.e., that of a combination of curved faces, constituting a dome rising from a plane surface. The River Abaeté produced a stone of 161½ carats in 1797, and another, later, of 48 carats. In 1906 a stone of some 600 carats was encountered in the River Verissimo, in Southern Goyaz, not very far from Bagagem, but was destroyed by being tested on an anvil with a sledge-hammer. A splendid brilliant, dating from colonial times, near to ruby red in colour, and weighing 2¾ carats. sold in London, in 1909, for £3,000.

The Irish crown jewels consist, as far as the diamonds are concerned, of Brazilian gems only, and many ancient stones of value are derived from the same source. Edward Streeter, in his book on precious stones, says that Minas Geraes produced in the first 20 years 144,000 carats of diamonds. Up to 1850, 5,844,000 carats, worth £9,000,000, were sold, and some £2,000,000 worth of contraband stones slipped through the fingers of the authorities.

In 1909 there were 456 claims in the Diamantina district, producing gems worth £200,000 from an area of 250,000 hectares. In 1911 this number was reduced to 437 claims.

The largest black diamond ever discovered in Brazil was brought to light in 1895 at Lençoes. It weighed 3,150 carats in the rough state. It is not uncommon to find comparatively large carbonados of from 500 to 900 carats. The monthly output averages about 2,500 carats, but, unless modern improvements are introduced, this figure is not likely to be maintained. Good carbons (and 95 per cent. of the stones found are good), when over ¾ carat, sell at about £5 per carat, and the smaller stones, from ½ to ¾ carat, mixed with globular diamonds or boart, sell at £1 10s. per carat. Very large carbons are worth rather less on account of the slight loss involved in breaking them up into marketable-sized pieces. Brazil enjoys the monopoly of the production of these carbonados, and the annual export of them from Bahia is reckoned to amount in value to £1,000,000.

MANGANESE.

The existence of manganese ores in close proximity to the gold deposits in Minas Geraes was known in the early years of the nineteenth century, but it was impossible to exploit them owing to the lack of transport

facilities. In 1890, when the railway reached Itabira, a small charcoal blast furnace, the Usina Esperança, was erected by Mr. Carlos Wigg. A lode of manganese was disclosed near Queluz, in a cutting made for the construction of the Central Railway. This was followed by further finds in the same locality, and, in 1894, by the discovery of the rich deposits at Miguel Burnier in the same State, where Mr. Wigg initiated the mining of manganese ores in Brazil. To-day the principal mines of this mineral are those of Miguel Burnier (in limestone) and Queluz (in a granite gangue), but large bodies of excellent quality have also been unearthed in the States of Bahia, Matto Grosso and Santa Catharina, while the presence of the metal in other parts of the country has also been proved. The deposits of the Morro d'Urucum and Morro Grande, in Matto Grosso, are estimated to contain 100,000,000 tons of ore.

The manganese deposits at Miguel Burnier stretch from that place in the direction of Ouro Preto, outcropping along the summits of a range of hills, and work is carried on over a distance of about five miles. The ore beds vary very much in thickness, and in some parts attain a depth of three metres. The ore is composed in great part of hard, metallic looking mineral, which shows bedding, and has been interstratified with softer and hydrated ore. The harder ore has a slight tendency to lay in lenticular blocks, and, while the proportion of hard ore varies with the situation, it generally averages about 80 per cent. of the whole. The softer ore is very generally charged with hygroscopic water, and is responsible for the somewhat high percentage of moisture that the Miguel Burnier ore shows in the rainy season. The metallic ore is exceptionally pure, the small quantity of metalosos being mostly concentrated in the softer material. The pyrolusite is the class of lode mainly exploited so far, but there is also a silicate kind. From analyses of

various layers, an average composition of the dry ore has been fixed as follows :—

	Per cent.
Metallic manganese ..	52·00 to 53·00
Iron	3·00 to 3·50
Silica	1·50 to 2·00
Phosphorus	0·03 to 0·04

More important than the proportion of the manganese content is the small ratio of siliceous matter and the freedom from phosphorous and sulphur.

Three years after Mr. Wigg began mining at Miguel Burnier, Messrs. Airosa & Co. commenced operations in the same neighbourhood, and while the former, between 1894-1899, produced 74,790 tons, the latter's output was 50,900 tons from 1897 to 1899. The official particulars of the export of manganese from Brazil commenced in 1901, and the figures for the following eight years are as follows :—

Years.	Tons of Ore.	Value (milreis, paper).
1901 ..	98,828 ..	2,841,948
1902 ..	157,295 ..	4,465,328
1903 ..	161,926 ..	4,959,562
1904 ..	208,260 ..	6,057,431
1905 ..	224,377 ..	5,087,311
1906 ..	121,331 ..	2,676,357
1907 ..	236,778 ..	8,009,785
1908 ..	166,122 ..	3,938,585

So far the working of the manganese lodes has been confined principally to the area of the original discovery, and some half-dozen companies are carrying on successful operations in the vicinity of Queluz, one of which is obtaining an annual yield of 60,000 tons. There are also deposits of this mineral, in the form of psilomelane at Goyanna (Pernambuco) and in the Chapada Diamantina, and the Serra de Jacobina, in Bahia, at Villa Nova, 444

kilometres from Bahia City. Another locality is at Nazareth, close to the city itself. Manganese is also found at Perus, in Sao Paulo, near Curityba, in Parana, and in the State of Rio de Janeiro itself.

Several lengths of railway have been built in Minas Geraes to connect the mines of the various companies working the manganese with the general system of lines. With the high percentage of metal in the ore-body, and the abundance of the deposits to be found in the various States, it is confidently believed that a great future lies before the production of manganese in Brazil. Already the export figures are beginning to assume some proportion in comparison with those of other countries that supply this metal to the world.

THE IRON SMELTING PROBLEM.

The question of smelting the iron and manganese ores will most probably find its solution in the electric system, which can be provided by the utilisation for generating purposes of the magnificent waterfalls of the country, six of which are among the largest in the world. According to Professor Gorceix, iron-smelting should prove most profitable in Brazil, provided that the works are erected close to a railway and in a district where the requisite fuel is readily obtainable from adjacent forests. In May, 1910, a law was passed granting certain privileges to companies formed to develop the iron resources, and, as a consequence, several foundries were projected. The Government commissioned a representative to visit the United States and study American methods in one of the great iron works. But want of the necessary capital, and the refusal of the Government to grant certain further privileges demanded by the companies, rendered the intentions of this law abortive. A second law passed in January, 1911, granted several privileges to various companies, and authorised the improvement of the

Central Railway, in order to provide better facilities for the transport of mineral, and the construction of new lines intended to encourage the development of the iron industry.

In the following month a further law was passed which granted to Messrs. Wigg and Trajano subsidies upon manufactured iron products, and other privileges on the working of an iron factory with a capacity of 150,000 tons per annum. The *Journal do Commercio* promptly condemned these concessions in the strongest terms, on the grounds that " each one would be sufficient to crush the iron industry and kill all those projects which had already such brilliant prospects. These privileges are: 1st, a premium of $25 average on each manufactured ton of iron; 2nd, promise of the Government to buy a third of all iron required at European prices, including in these prices the duties established in the present custom tariff, even in the case of these duties being subsequently abolished; 3rd, transport at reduced rates on the Central Railway of all mineral for exportation up to the limit of 1,500,000 tons. The premiums amount to nearly 4,000 contos yearly, which amount will go into Messrs. Wigg and Tragano's pockets, since these gentlemen will be the only persons able to manufacture (in case of a monopoly) the 1,500,000 tons of iron which is the amount required in our market. . . . The iron industry of a country does not depend on the establishment of only one factory, no matter how large its output may be, but on the establishment of many, wherever there may be mines to work; thus, by the general competition, to produce the most and the most cheaply, in order to conquer the market to the advantage of the general public. That is the only true method for bringing progress and prosperity to the country."

Without entering into the merits of this contention, it is only just to Mr. Carlos de Costa Wigg, who figures

conspicuously in connection with Brazilian mining, to refer to the fact that, but for his enterprise, energy and prescience, Minas Geraes would be without a foundry at the present time. It was he who constructed the Esperança furnace, near Itabira do Campo, in 1888, which has operated successfully ever since. It was he, again, who, in 1890, founded the Usina Wigg in the neighbourhood of Burnier Station, which is still in a flourishing condition. From Burnier Station Mr. Wigg has constructed a narrow-gauge railway to three stations on his estate. The Miguel Burnier Mine employs 300 men, and mines about 50,000 tons of manganese ore annually, or about a quarter of the Brazilian output. The ore is sent by rail to Rio de Janeiro, where it is transported in Mr. Wigg's tugs and lighters to the island of Mocangue Grande, in the bay, where he has his own stores, which are equipped with cranes and automatic loading and discharging gear. For some years past he has experimented, with more or less success, in gold-dredging in the rivers of Minas Geraes, and he is at the head of a project for establishing great iron and steel works near the town of Juiz de Fora, in that State. It is claimed that the scheme will revolutionise the mineral industries of the country, and it is certain that its consummation has only been made possible by the perseverance of Mr. Carlos Wigg and his unwavering faith in the possibilities of the country's mineral industries.

PLATINUM IN MINAS GERAES.

Over a century ago Dr. W. H. Wollaston announced the discovery of native palladium in the platiniferous and auriferous deposits of Serra do Espinhaço. In the "Transactions" of the Institute of Mining Engineers (1904), Eugen Hussak records the occurrence of the metal in the native state in the itabirites of Itabira do Matto Dentro. It more frequently occurs in Brazil in the form

of an alloy with gold, as at the Gongo Soco Mine, and in the contact-altered limestones of Candonga, Minas Geraes. The percentage of palladium in this alloy varies from 5 to 8. The Candonga Mine has been abandoned, but palladium-gold of a pale copper-red colour is traced in tailings from the Itabira do Matto Dentro district. The occurrence of these native alloys had not until about twenty years ago been recorded from any other country than Brazil, but palladium is now said to have been found associated with the gold of certain Russian placer deposits. The existence of native platinum in some of the Brazilian gold placers was known in 1801, and the probability that palladium-gold was often mistaken for platinum in the researches of the last forty years has greatly lengthened the list of Brazilian localities for platinum. Hussak is of the opinion that the platinum found in the Rio Abaté and its left bank tributaries, which is strongly magnetic, contains much iron and is free from palladium, is probably derived from peridotites. Platinum from Conceiçao and Condado, Serro, are both non-magnetic, but the latter variety is rich in palladium, while the former is free from it. Along the eastern slopes of the Serra do Espinhaço, platinum occurs in association with diamonds derived from conglomerate quartzite, but in such singular shapes that it must have been redeposited from solution—the outcome, probably, of the decomposition of platiniferous pyrites such as are known to occur in the United States and in Norway. Platinum has also been found in the auriferous quartz veins which traverse the crystalline schists of the Rio Bruscus, Pernambuco.

MICA PRODUCTION IN BRAZIL.

To the three principal mica-producing countries—British India, Canada and the United States—must be added Brazil, in which mica occurs in workable quantities

in the States of Goyaz, Bahia and Minas Geraes. No exact information is available with regard to the deposits of mineral in Goyaz or Bahia, the quantity of mineral exported from those States being small, although the mica produced from Goyaz is of excellent quality. The principal mine deposits are pegmatite veins, lenses or dykes, which occur in the metamorphic schists near the City of Santa Luzia de Carangola, on the borders of the States of Minas Geraes and Espirito Santo; it is from these deposits that practically all the micas exported from Brazil have been obtained. The country varies in height between 2,500 ft. to 4,000 ft. above the level of the sea, and the pegmatite veins run in an almost north and south direction along the side of the Cayama and Popogais mountain ranges which form the watershed between the Rivers Sao Joao do Rio Preto and Carangola.

According to Mr. Kilburn Scott, the rocks of Brazil, more particularly the metamorphic schists and in the regions where the pegmatite veins are seen, are decomposed to a great depth. These veins seem to run parallel to each other, and some of them continue for considerable distances, and he records a series of outcrops all in a line on several hills, one after another, apparently all belonging to one and the same vein. Owing to the country being thickly wooded, the outcrops of the pegmatite veins are not easily discovered, but the presence of the pegmatic vein may be located by the projecting bosses of quartz. The veins are from 20 ins. to 10 ft. in width, and generally consist of kaolin, resulting from the decomposition of felspar, in which masses or "books" of mica are disseminated irregularly. The dimensions of the mica "books" vary considerably; "books" which are 10 ins. by 20 ins. by 6 ins. may be met with, but the average size is much smaller than this, say 6 ins. by 6 ins. by 3 ins., while the mica plates are often as small as those seen in an average mica schist. Only a small

proportion of the " books " contain mineral of sufficiently good quality for export, and this is especially the case with mica got near the surface where surface agencies have affected its quality.

Indian mica has hitherto had the command of the mica market of the world, but, as Mr. Kilburn Scott asserts, in a paper read before the Institution of Mining and Metallurgy, " as the Brazilian industry is developed this will no longer be the case. Undoubtedly, India enjoys many advantages, such as cheap labour, large and plentiful deposits ; but, on the other hand, work can only be carried on for about nine months of the year, owing to the bad climate, and, in addition to this, the mineral must be transported from 35 to 70 miles before it reaches a railway. The facilities for mica mining in Brazil are very great. The low cost of mining for the mineral due to the decomposed character of the rocks, its good quality and the contiguity of the deposit in the Santa Luzia district to the Leopoldina Railway are points which will weigh in favour of the Brazilian mica industry when comparing its conditions with those of other countries."

PRESENT POSITION OF THE MINERAL INDUSTRY.

Although rich in her store of gold and precious stones, geologists are agreed that more importance attaches to Brazil's possession of her massive lodes of the richest quality of iron ore. But although the discovery of these deposits was made as early as the end of the sixteenth century, relatively little has been done in the way of their development. Lack of capital and of operative skill, the difficulty of transport and the existence of ill-judged mining regulations, have acted as deterrents upon the production of iron. Baron von Eschwege, a Prussian military engineer, was appointed in 1910 to examine into the state of the mining industry of the country

with a view to initiating modern methods of mining, and his reports contain the most reliable information we have concerning the operations of that period. In 1800 an attempt to revive the production of iron by the high furnace process had proved unsuccessful, and in 1812 Eschwege erected a direct process plant near Ouro Preto which produced a hundredweight of iron per diem. The direct process was adopted with something like enthusiasm, and presently the whole district was dotted with little furnaces—in 1864 as many as 120 of them were operating. Between 1810 and 1818, four large direct process furnaces were operating in the district, and in the latter year two high furnaces were put into action by a German engineer officer and continued to produce 3 to 4 tons daily until 1895. Between 1809 and 1814 an unsuccessful attempt was made to establish a high furnace at Morro de Pilar, Serro, and it was not until 1888 that a high furnace, with a capacity of 4 tons daily, was put into blast at Esperance, near Itabira do Campo. This furnace, the capacity of which was subsequently raised to 6 tons, has operated successfully ever since.

Dr. Derby admits that the inglorious record of the industry is naturally suggestive of the existence of natural conditions unfavourable to the development of an iron industry in the country. "Such unfavourable conditions exist," he says, "but for our present purpose it is sufficient to say that a deficiency of ore of excellent quality and in good working conditions is not one of them." This conclusion is supported by Mr. Kilburn Scott, who in a paper delivered before the American Institute of Mining Engineers in 1902, says: "The ores of Minas Geraes certainly belong to the low-grade class; but the gold-field possesses many natural advantages, such as healthy and moderate climate, permitting work at all seasons; facility of transport, abundance of water power, cheap labour and good timber, to say nothing of

a sympathetic government. Of failures, this State, like every other gold-field in the world, has had not a few. Most of them, however, can be traced to incompetent technical or business management and the lack of adequate appliances."

RAILWAY ENTERPRISE.

Monsieur Gabriel Hanotaux, in his preface to the works of Barao D'Anthouard, likened Brazil to a figure representing prodigious wealth which eluded capture by retreating before all who sought to grasp it. The extension of the railway system into the interior has enabled the prospector and miner to secure a strangle hold on the rich mineral reserves, if not to convey the captive readily to market. As it is, the lines are bringing even the remoter mining districts of the Republic into touch with twentieth century enterprise and capital, and the Hanotaux simile no longer applies.

But while the economic development of Brazil is essentially dependent upon her railways, the political unsettlement in the country has served to seriously retard this factor in her progress. The first three presidents of the Republic were too much engaged in striving to maintain peace and order to devote much time to broadening the scope of their administration, while President Dr. Campos Salles (1898-1906) found sufficient occupation in the task of organising the national finances during this period of unrest, to preclude him giving much attention to railway necessities. It therefore remained to President Dr. R. Alves (1902-1906) and his successors, to place the railway movement on a definite footing.

The history of Brazil's railway enterprise is thus of comparatively recent origin, and the principal problem in relation to her mineral deposits in Minas Geraes is, of course, that of transportation. For more than a

quarter of a century the Central of Brazil Railway, owned and operated by the Brazilian Government, has run northward from Rio de Janeiro through the centre of the iron-ore district. At the present time it continues far to the north of Pirapora on Rio Sao Francisco, from which point it is possible to travel by steamer and railway to Bahia. The Central of Brazil is a broad-gauge line from Rio de Janeiro as far as Miguel Burnier, a distance of about 310 miles, and beyond that point it continues northward with a narrow gauge. From Miguel Burnier a branch line runs eastward to Ouro Preto and Marianna, while another branch line runs eastward from Sabara to Caethé and Santa Barbara. The latter branch is being extended to Itabira do Matto Dentro. From General Carneiro, north of Sabara, a branch line runs south-westward to Bello Horizonte, the present capital of Minas Geraes. A broad-gauge line is now under construction from Lafayette, a point at the southern extremity of the iron-ore district, to Bello Horizonte by way of Rio Paraopeba, which will form a direct broad-gauge connection between Bello Horizonte and Rio de Janeiro.

The Leopoldina Railway has a network of lines in the south-eastern region of Minas Geraes and in the neighbouring States of Espirito Santa and Rio de Janeiro. Saude, the terminus of one of its northernmost branches, lies about 20 to 25 miles east of the eastern border of the iron-ore district. The main line of the West of Minas Railway is some distance west of the mineral area, but it has a one metre gauge branch which runs into Bello Horizonte from the west.

The gold and iron properties in the St. John del Rey, the Itabira do Campo and the Sao Vicente districts are all on the Central of Brazil Railway, which was not planned as an ore-carrying road. Heavy grades and sharp curves abound over large portions of the line. The Brazilian

Government, however, has taken several contracts for hauling iron ore over this road to Rio de Janeiro, from points in the western part of the iron-ore district, at the rate of 6/- per ton. Small shipments of manganese ore are being transported over the Central system at the present time, and, judging from the difficulties encountered in this traffic, it seems probable that much reconstruction will be necessary before this railroad can handle even a small fraction of the iron ores which must ultimately be transported from the district. It seems probable, therefore, that by far the greater part of the mineral output will eventually be carried from the district by the Victoria to Minas Railway, which leaves the sea coast at Victoria and runs up the Rio Doce.

The Victoria to Minas line, which is now in course of construction, will enter the iron-ore district from the north-east, and will tap first those deposits which are now the furthest removed from lines of transportation. But although this railway is working over a considerable distance, much difficult country will have to be got through and a number of cuttings made before it is finished, and large capital will be required to complete the extension to the mining region. When, however, the connection is made, it will not be a difficult matter to get the ore down to the coast, as the gradient is easy and the track is downhill for a considerable part of the way. The distance to Victoria from the eastern part of the iron-ore area over this route is about 375 miles, about 275 miles of which has been completed, but the greater part of this will probably need reconstruction, as, in the original plans, this was not intended to be an ore-carrying road.

The Itabira Iron Ore Syndicate, which is working the Conceiçao, Caué and Santa Anna properties in the Itabira do Matto Dentro district, propose to send their ores to the coast by the Victoria to Minas Railway. The

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Leopoldina Railway controls the port, and when the line is completed, the Itabira Syndicate will arrange with the railway company to spend a considerable sum of money in constructing sidings which will enable them to bring boats alongside and shoot the ore into them from the railway trucks.

What appears to be the most important railway project in connection with the iron industry of eastern central Minas Geraes is one that will connect the deposits in the Itabira do Matto Dentro district with a deep-water port on the coast. The concessions granted in connection with this scheme include one for a line to the Minas-Espirito Santo border, and several granted by the coastal State of Espirito Santo for lines from the Minas Geraes border to the sea. As soon as the railway engineers have selected the port of terminus, the various existing Espirito Santo concessions would be cancelled and the privileges incorporated in a new charter, carrying a State guarantee of 6 per cent. on the capital necessary to build the line on the basis of about £7,300 per mile. The total length of the line from Itabira to the coast (the concessions are for a double line of one metre gauge) would be approximately 250 miles, of which about 100 miles would be in the State of Espirito Santo and 150 in the State of Minas. The length of this line is about 125 miles shorter than the route selected by the Itabira Company to the Port of Victoria. As far as known, there would be no difficult engineering works required in the construction of this line, which, in the State of Espirito Santo, would traverse some of the best watered and most fertile country in Brazil, and in the State of Minas would be in close proximity to the best known iron deposits of the Matto Dentro district. There are, moreover, several deep-water ports south of Victoria which would be open to the selection of the engineers. The foreshore rights of the port selected could be acquired on very moderate terms

and would thereby enable the port to be a private port.

Most of the lines at present under construction in Brazil are either undertaken by the Federal Government, or under concession from the Federal Government, and the following information taken from a recent report made by the United States Consul-General at Rio de Janeiro, as to the methods pursued by the Brazilian Government in granting railway concessions, is of interest: "Various contracts have been made for the various roads or systems, but in general the principle followed in the construction of most of them has been the payment for construction by Government bonds issued for the purpose, the contract with the concessionaires providing that the roads, when operating, shall have all net earnings first applied to the payment of interest on and for the amortization of such bonds, the excess, if any, to go to the concessionaires as profit. Generally the concessionaires take a contract for financing the road, for its construction, and for its operation for a fixed period. Most of the contracts provide for a limit of the cost of construction per unit (kilometre), bonds being issued at an agreed rate for the actual cost up to that limit."

It is to be noted, however, that "contracts for such work are made with the Government with Brazilian concerns only, or with foreign firms domiciled and authorised to do business in Brazil." There is a lot of such work being done in Brazil at the present time, and an immense amount of it in prospect, but no foreign interests can expect to do anything in this connection without Brazilian agencies.

VIEW ON THE ROAD FROM RIO.

PLATE 2.

LAFAYETTE.

OURO PRETO. FORMER CAPITAL OF THE PROVINCE OF MINAS GERAES, BRAZIL.

CAT. NO. PLATE 3.

ITABIRA DO CAMPO. NEW PART OF THE TOWN.

PLATE 5.

ITABIRA DO CAMPO. THE OLD PART OF THE TOWN TAKEN FROM THE RAILWAY BRIDGE.

PLATE 6.

PART OF MORRO VELHO.

PLATE 7.

PART OF MORRO VELHO.

PLATE 8

QUELUZ, CLOSE TO LAFAYETTE. TYPICAL SMALL BRAZILIAN TOWN.

PLATE 9.

ONE END OF THE VILLAGE OF CONGONHAS.

PLATE 10.

CUBECES, NORTHERN END OF OURO PRETO.

PLATE 11.

SABARA.

PLATE 12.

NEAR SABARA.

PLATE 13.

SAN LUIZ MOUNTAIN.

VIEW OF A LOWER REACH OF THE PIRAICABA RIVER.

PLATE 14.

CAETHE.

IRON ORE DEPOSITS NEAR MORRO VELHO.

PLATE 16.

NEAR SABARA. IRON ORE IN DISTANCE IN SERRA DE PIEDADO.

PLATE 17.

MINE MANAGER'S RESIDENCE, SERRA DE OURO BRANCO, ON RIGHT.

PLATE 18.

TYPICAL SMALL VILLAGE IN MINAS GERAES.

PLATE 19.

MORRO VELHO MINE. ST. JOHN DEL REY MINING CO., LTD.

A VIEW AT THE MORRO VELHO MINE. ST. JOHN DEL REY MINING CO., LTD.

MORRO VELHO MINE. ST. JOHN DEL REY MINING CO., LTD.

PLATE 21

MORRO VELHO MINE. ST. JOHN DEL REY MINING CO., LTD.

PLATE 23.

VIEW OF PASSAGEM MINE. OURO PRETO GOLD MINES OF BRAZIL, LTD.

SAO BENTO. ELECTRIC LOCOMOTIVE WITH TRAIN OF MINE WAGONS LOADED WITH GOLD ORE ON ITS WAY FROM MINE TO MILL.

SAO BENTO. THE METHOD OF TRANSPORT BEFORE THE RAILWAY, 5 TON LOAD ON WAGON, CROSSING SAO JOAR RIVER.

PLATE 25.

TRANSPORTING "TUBE MILL" OVER GONGO HILL. TRANSPORT BY THIS METHOD COST £10 PER TON, AND TOOK FROM THREE WEEKS TO THREE MONTHS ON THE ROAD. THE RAILWAY IS NOW COMPLETED TO THE MINE.

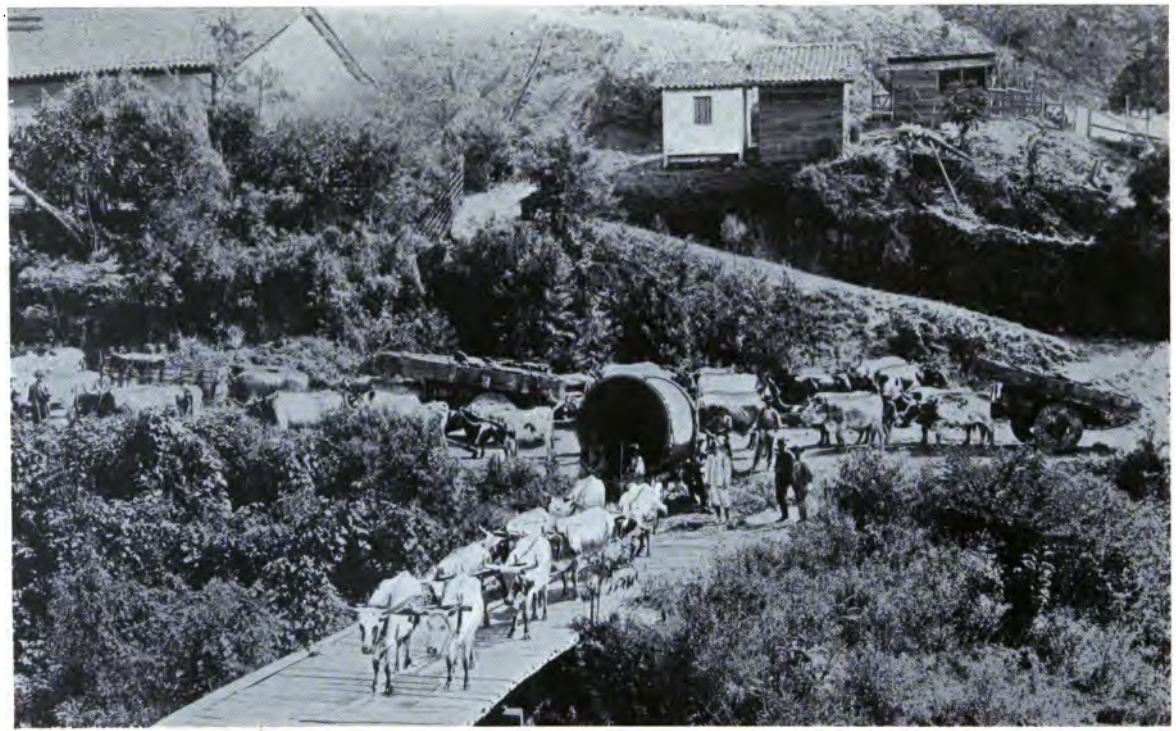
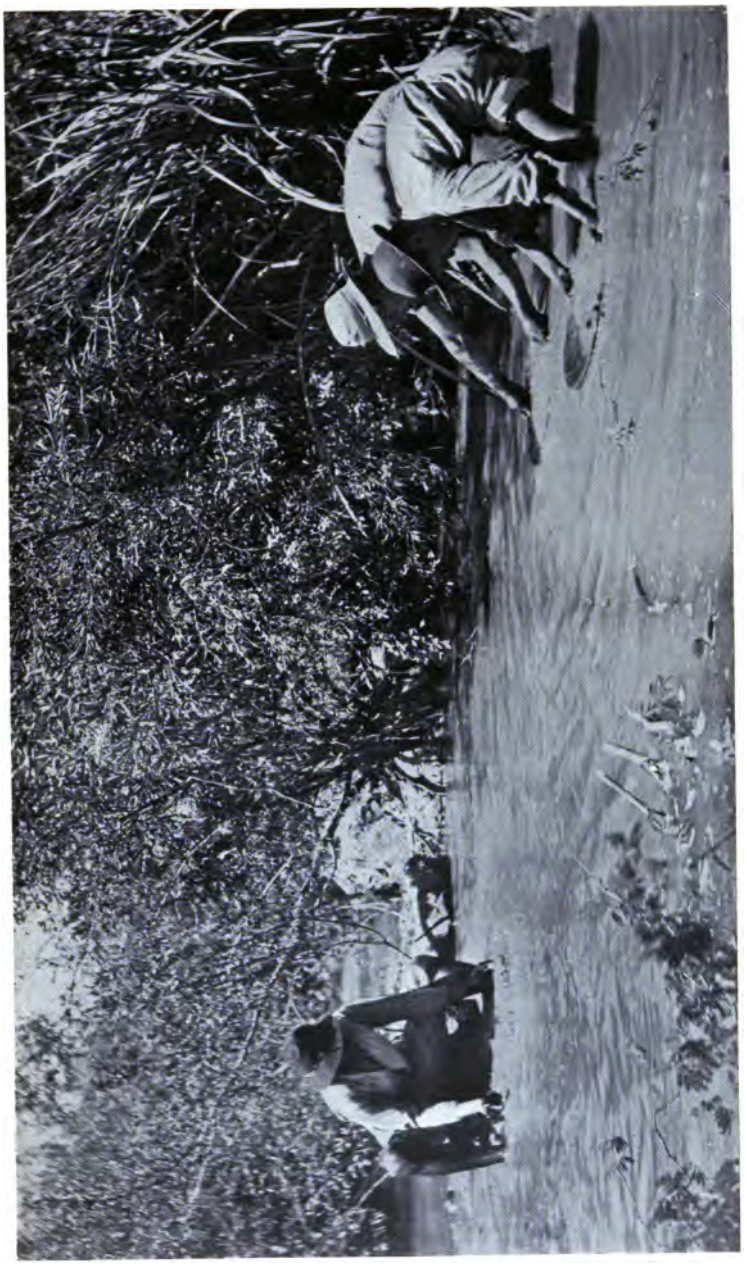


PLATE 27.

SAO BENTO. MATERIAL ARRIVING AT CAMP.

NATIVES CARRYING GRAVEL TO THE RIVER TO WASH FOR GOLD.



NATIVES WASHING FOR GOLD.

PLATE 30.

WATER WHEEL ENCLOSED. THIS WHEEL IS ATTACHED TO ONE STAMP PROSPECTING MILL, PITANGUY DISTRICT.

PLATE 31.

ONE STAMP GOLD PROSPECTING MILL, PITANGUY DISTRICT.

PLATE 32.

FARM AND GOLD MINE COMBINED, WORKED BY AN ENGLISHMAN, STA. BARBARA DISTRICT.

PLATE 33.

OLD GOLD WORKINGS.

PLATE 34.

A PROSPECTING SHAFT ON A GOLD MINE.

PLATE 35.

SLUICING FOR ALLUVIAL GOLD.

PLATE 36.

SAO BENTO GOLD MINES.

PLATE 37.

SAO BENTO MINE. COMPRESSOR HOUSE, NO. 2 ADIT, NO. 7 LEVEL.

PLATE 38.

SAO BENTO MINE. ELECTRIC SUB-STATION SHOWING IN-GOING AND OUT-GOING CIRCUITS.

PLATE 39.

SAO BENTO MINE. FIRST ELECTRIC LOCOMOTIVE USED UNDERGROUND IN BRAZIL.

OLD HOUSE AT GONGO SOCO, ONCE THE RICHEST GOLD MINE IN BRAZIL.

PLATE 40.

PLATE 41.

OLD-FASHIONED BRAZILIAN WOODEN STAMPS.

MARIANNA, MINAS_GERAES.

PLATE 42.

RIO CARMO, NEAR MARIANNA.

PROSPECTING FOR GOLD ON THE RIO CARMO, NEAR MARIANNA.

PLATE 44.

ALLUVIAL GOLD FLATS ON THE RIO CARMO, NEAR MARIANNA.

MARIANNA, MINAS GERAES.

PLATE 46.

PLATE 47.

SMALL FARMHOUSE NEAR MIGUEL BURNIER.

MIGUEL BURNIER WORKS. USINA WIGG AND EMPLOYEES.

PLATE 6.

MIGUEL BURNIER MINES. FOUNDRY, ETC., ON RIGHT, OFFICE AND LABORATORY ON LEFT.

MIGUEL BURNIER MINES. PLATFORM FOR LOADING ORE IN TWELVE TON WAGONS.

MIGUEL BURNIER MINES. MASSIVE OUTCROP TO LEFT AND WORKINGS AT AN EARLY STAGE. OX-WAGONS LOADING ORE TO TAKE TO RAILWAY.

MIGUEL BURNIER MINES. WORKINGS SHOWING PILES OF ORE.

PLATE 54.

MIGUEL BURNIER MINES. VIEW OF THE MINES AND MINERAL RAILWAY. SERRA DE OURO BRANCO IN THE DISTANCE.

MIGUEL BURNIER MINES. "THE EUCASTA" (HILLSIDE) WORKINGS. VIEW LOOKING ALONG THE LINE OF STRIKE OF BED. THE TIP-WAGON IN CENTRE MARKS POSITION OF BED, WHICH IS HERE ALMOST VERTICAL, AND ABOUT 9 FEET THICK AND OF BEST QUALITY.

PLATE 55.

SERRA DE PIEDADE FROM CUIABA IRON RANGE, NEAR SABARA.

PLATE 56.

OURO BRANCO (ON LEFT). MIGUEL BURNIER IN THE DISTANCE.

MIGUEL BURNIER MINES. THE LAMINATED ROCK TO LEFT IS THE SANDY FERRUGINOUS SCHIST OR JACUTINGA. THE LINE **A** MARKS THE JUNCTION WITH THE MANGANESE ORE, DISTINGUISHABLE BY ITS MASSIVE APPEARANCE. RED CLAY ON RIGHT.

PLATE 57.

PLATE 58.

QUARTZITE ROCKS CROPPING OUT ALONG THE TOP OF THE PICO DE ITABIRA RANGE.

PICO D'ITABIRA DO CAMPO.

This wonderful peak is of massive hematite. The summit is about 250 feet above the level of the foreground, and it is about 150 feet across at the top. The slopes are covered with rubble and conglomerate ore.

PLATE 60.

ON THE ROAD NORTH FROM RIO.

PLATE 61.

WATER POWER IN THE IRON DISTRICT, SANTA BARBARA.

PLATE 62.

ON THE ROAD TO THE PICO DE ITABIRA. COFFEE, BANANA, AND ORANGE TREES GROWING IN THE "QUINTAL" ROUND THE HOUSE.

PLATE 63.

AN OUTCROP OF SOLID IRON, IRON PEAK, ITABIRA DO CAMPO.

PLATE 64.

PITANGUY IRON DEPOSITS, SOUTH END OF PROPERTY. ANCIENTS WASHED FOR GOLD ON THIS PROPERTY.

PLATE 65.

FORMATION NEAR ITABIRA DO CAMPO.

PLATE 66.

PEAK OF ITABIRA DO CAMPO.

PLATE 67.

TRANSPORTING MACHINERY UNDER DIFFICULTIES.

PLATE 68.

TRANSPORT OF MACHINERY.

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PLATE 69.

BRAZILIAN CART.

PLATE 70.

GROUP OF BRAZILIAN NATIVE MINERS.

PLATE 71.

MR. E. A. MANNHEIM—ONE OF THE PIONEERS.

PLATE 72.

MESSRS. WILLIAM JONES, JAMES MILLER, AND ANOTHER WELL-KNOWN MINING MAN.

PLATE 73.

RIO S. FRANCISCO IN THE IRON DISTRICT, STA. BARBARA.

PLATE 74.

BRAZILIAN CARTS.

PLATE 75.

VIEW OF THE MANGANESE DEPOSITS, SAN LUIZ DISTRICT.

PLATE 76.

WATER POWER IN THE IRON DISTRICT, STA. BARBARA.

ITABIRA DO MATTO DENTRO. ESMERIL IRON DEPOSITS IN THE DISTANCE.

PLATE 78.

ITABIRA DO MATTO DENTRO. GIRAV IRON DEPOSITS IN DISTANCE TO RIGHT.

ITABIRA DO MATTO DENTRO. THE FAMOUS IRON PEAK OF CAUÉ.

CONCEICAO DOS COREGOS, AND OUCA. ITABIRA DO MATTO DENTRO.

THE FAMOUS IRON PEAK OF CAUÉ.

LADO DE "NASCENTE." SERRA DE ITABIRA DO MATTO DENTRO.

LADO DO "POEUTE." SERRA DE ITABIRA DO MATTO DENTRO.

PLATE 8.

PLATE 84.

IRON OUTCROP ON CONCEICAO.

PLATE 85.

IRON DEPOSITS AT CONCEICAO.

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PLATE 86.

VIEW OF THE GREAT IRON PEAK OF CAUÉ.

PLATE 87.

IRON OUTCROP ON CAUÉ.

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PLATE 88.

NEAR SUMMIT OF SERRA DE PIEDADE (CONVENT ON TOP).

PLATE 89.

RICH IRON ORE ON SURFACE.

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PLATE 90.

IRON DEPOSITS, SERRA DO CARACA.

PLATE 91.

IRON ORE DEPOSITS AT SERRA DO CARACA.

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PLATE 92.

PARACATU. VIEW OF AGUA QUENTE IN VALLEY.

PLATE 93.

PITANGUY. FACE OF QUARRY.

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PARACATU. SHOWING CLOUDS ON HILL.

PLATE 95.

BANANAL, SERRA CARACA ON LEFT, IRON HILL ON RIGHT IN FOREGROUND.

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PLATE 96.

IRON MOUNTAINS. PARACATU ON LEFT, M. ALMAS IN CENTRE, PITANGUY TO RIGHT.

PLATE 97.

PITANGUY, SERRA CARACA, FROM CHURCH SQUARE, CATTAS ATLAS.

PLATE 98.

N. FACE OF CERRO FROM THE BASE ON EDGE OF THE RIVER.

PLATE 99.

EASTERN FACE OF THE SAN LUIZ MOUNTAIN, SURFACE STRIPPED CLEAN. HIGHEST GRADE OF IRON ORE 69·2% IRON.

PLATE 100.

GONGO SOCO. ALL THESE ROCKS ARE IRON ORE, AND IT IS THE SAME BOTH SIDES OF THE RIDGE.

PLATE 101.

APPROACH TO IRON MOUNTAIN, SERRA DO CARACA.

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MORRO AGUDO PEAK. SANTA BARBARA DISTRICT.
THIS WHOLE OUTCROP IS PURE SPECULAR IRON.

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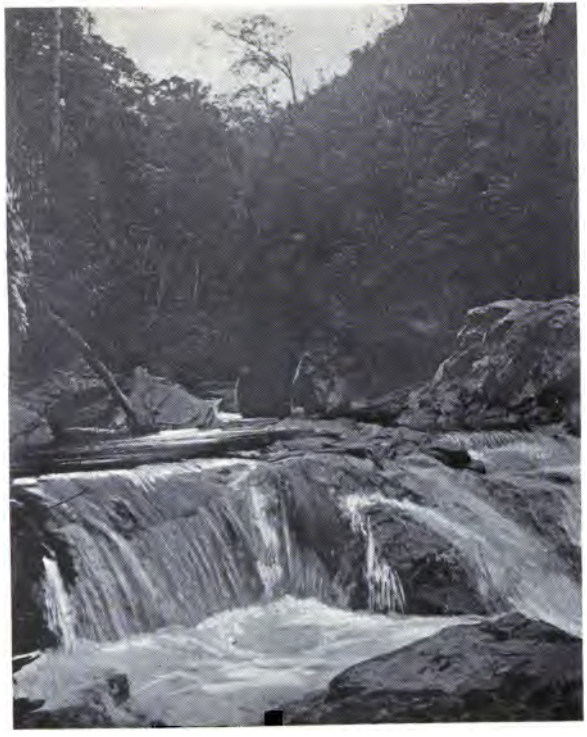
SAMPLING IRON ORE.

PLATE 104.

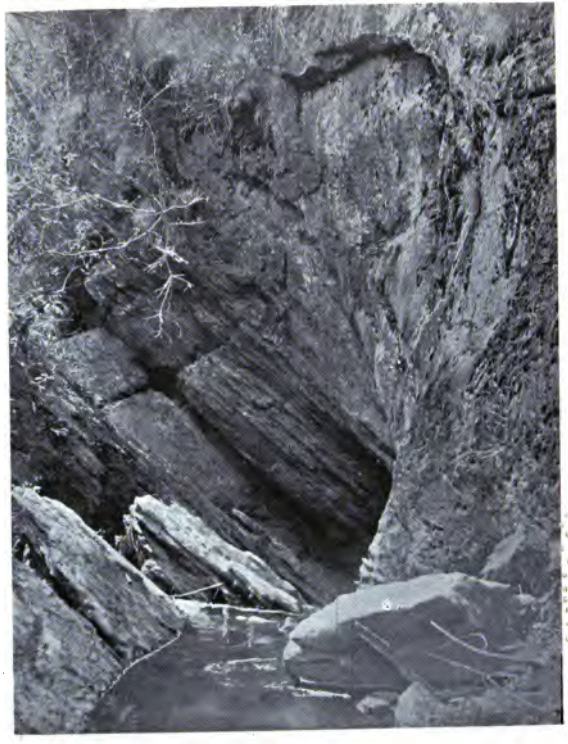
IRON ORE LAND, MORRO VELHO.

PLATE 105.



CRYSTAC'S WATERFALL, NEAR MORRO VELHO.

PLATE 106.



ITABIRITE AND LIMESTONE.

FOLDING OF ITABIRITE.

PLATE 92.

PARACATU. VIEW OF AGUA QUENTE IN VALLEY.

PLATE 93.

PITANGUY. FACE OF QUARRY.

UNIV. OF CALIFORNIA

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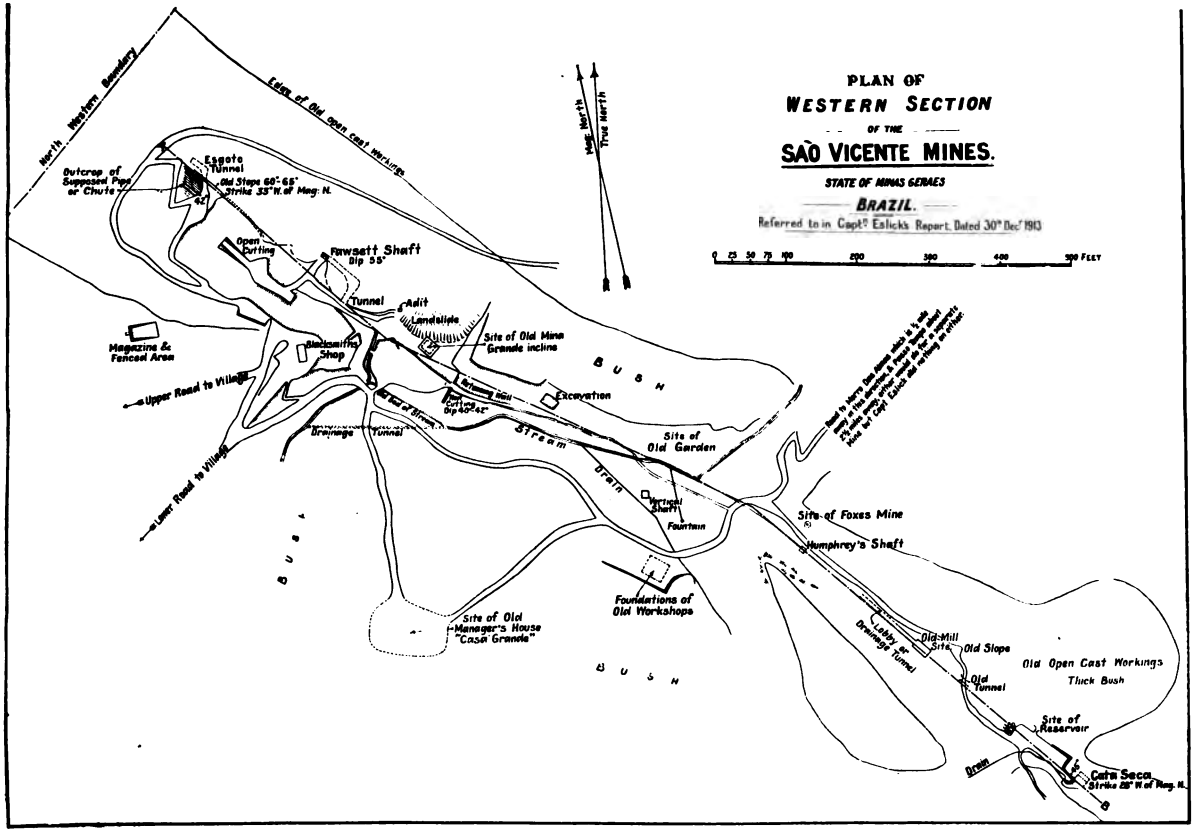
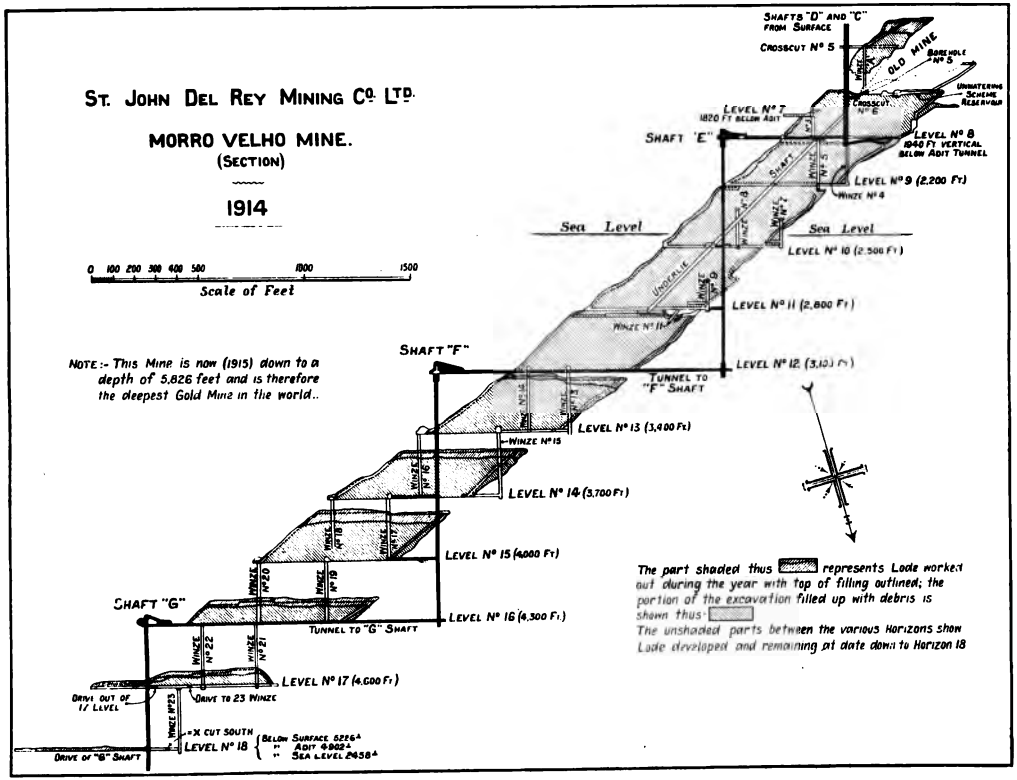
FOLDING OF ITABIRITE.



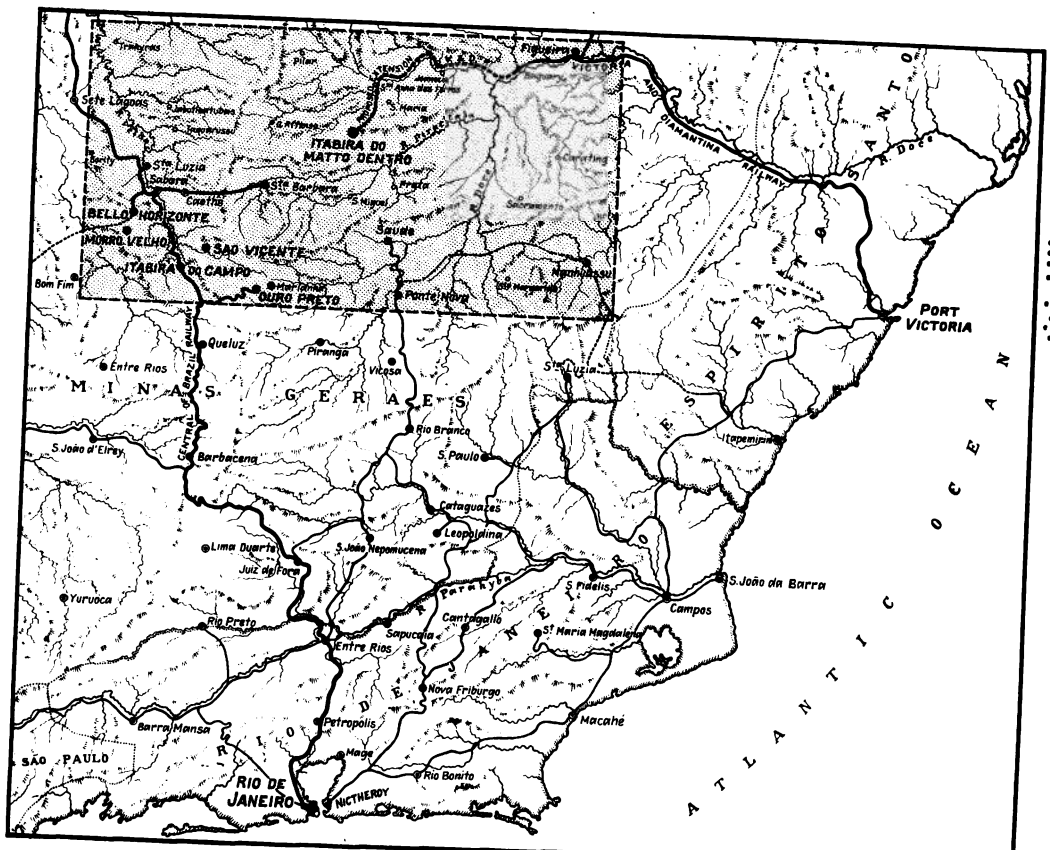
PLAN OF SOME OF THE GOLD MINES AT SAO VICENTE BELONGING TO THE PARRAL MINING CORPORATION, LTD.

PLATE I.G.

PLAN SHOWING LINE OF RAILWAY FROM RIO DE JANEIRO TO ITABIRA, SAO VICENTE, OURO PRETO, AND BELLO HORIZONTE DISTRICTS.

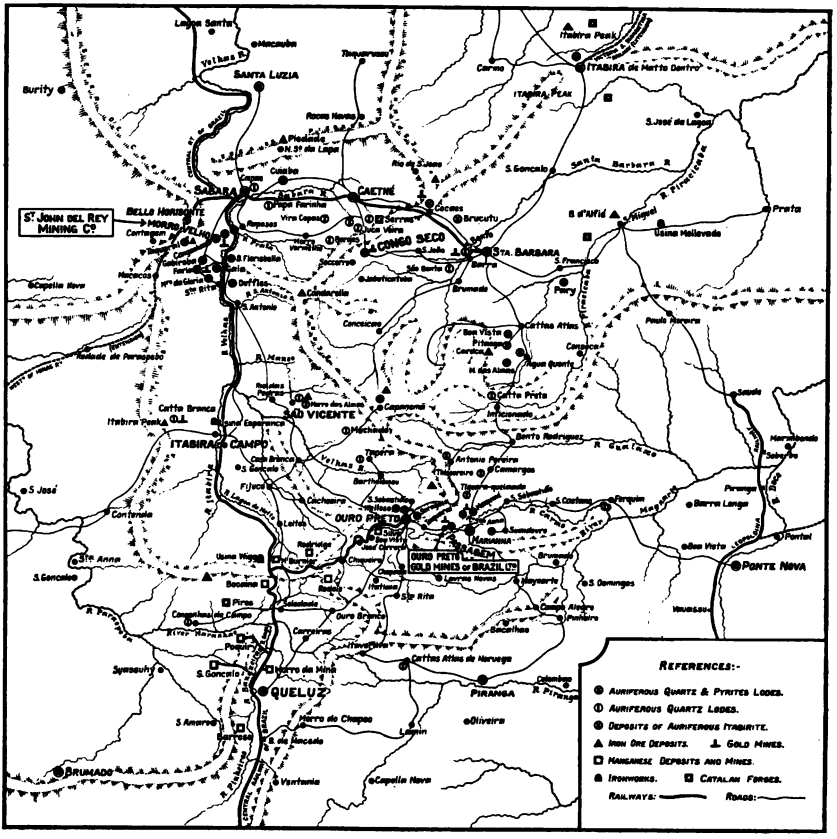

ST. JOHN DEL REY MINING Co. LTD.
MORRO VELHO MINE.
(SECTION)
1914
0 100 200 300 400 500 1000 1500
Scale of Feet
NOTE:- This Mine is now (1915) down to a depth of 5,826 feet and is therefore the deepest Gold Mine in the world..
SHAFTS "D" AND "C" FROM SURFACE
CROSSCUT Nº 5
OLD MINE
BORE HOLE Nº 5
UNWATERING SCHEME RESERVOIR
CROSSCUT Nº 6
LEVEL Nº 7 1820 FT BELOW ADIT
SHAFT "E"
LEVEL Nº 8 1940 FT VERTICAL BELOW ADIT TUNNEL
LEVEL Nº 9 (2,200 Ft.)
WINZE Nº 4
Sea Level
Sea Level
LEVEL Nº 10 (2,500 Ft.)
LEVEL Nº 11 (2,800 Ft.)
WINZE Nº 11
SHAFT "F"
LEVEL Nº 12 (3,100 Ft.)
TUNNEL TO "F" SHAFT
LEVEL Nº 13 (3,400 Ft.)
WINZE Nº 15
LEVEL Nº 14 (3,700 Ft.)
LEVEL Nº 15 (4000 Ft.)
SHAFT "G"
TUNNEL TO "G" SHAFT
LEVEL Nº 16 (4,300 Ft.)
LEVEL Nº 17 (4,600 Ft.)
DRIVE OUT OF I7 LEVEL
DRIVE TO 23 WINZE
X CUT SOUTH
LEVEL Nº 18
BELOW SURFACE 5226 A
ADIT 4002 A
SEA LEVEL 2458 A
DRIVE OF "G" SHAFT
The part shaded thus represents Lode worked out during the year with top of filling outlined; the portion of the excavation filled up with debris is shown thus:
The unshaded parts between the various Horizons show Lode developed and remaining at date down to Horizon 18

SECTION OF THE MORRO VELHO MINE, ST. JOHN DEL REY MINING COMPANY, LTD.



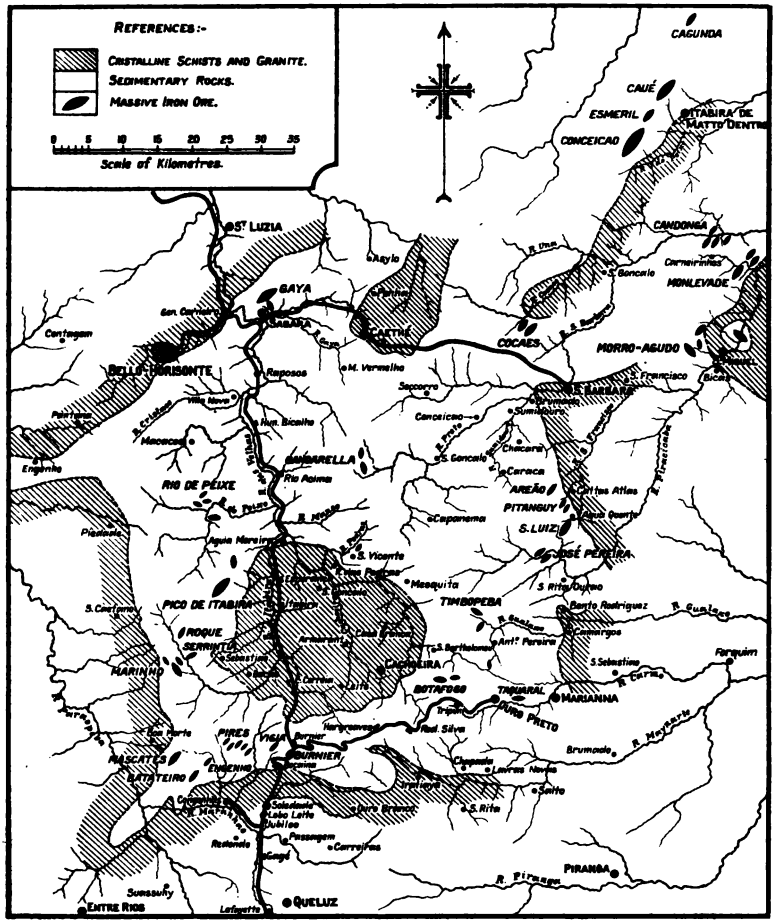
PLAN SHOWING THE PRINCIPAL IRON DISTRICTS OF BRAZIL.

UNIV. OF CALIFORNIA



PLAN SHOWING THE MINERAL DEPOSITS IN THE PROVINCE OF MINAS GERAES.

PLATE 42a.



GEOLOGICAL PLAN OF MINAS GERAES, SHOWING IRON DEPOSITS.

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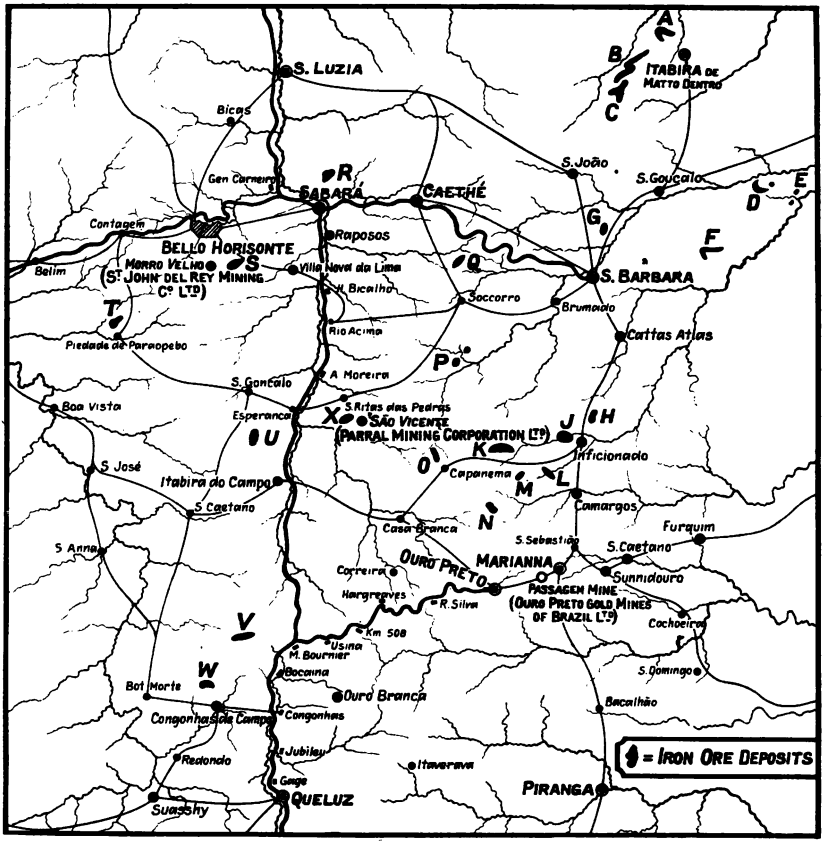
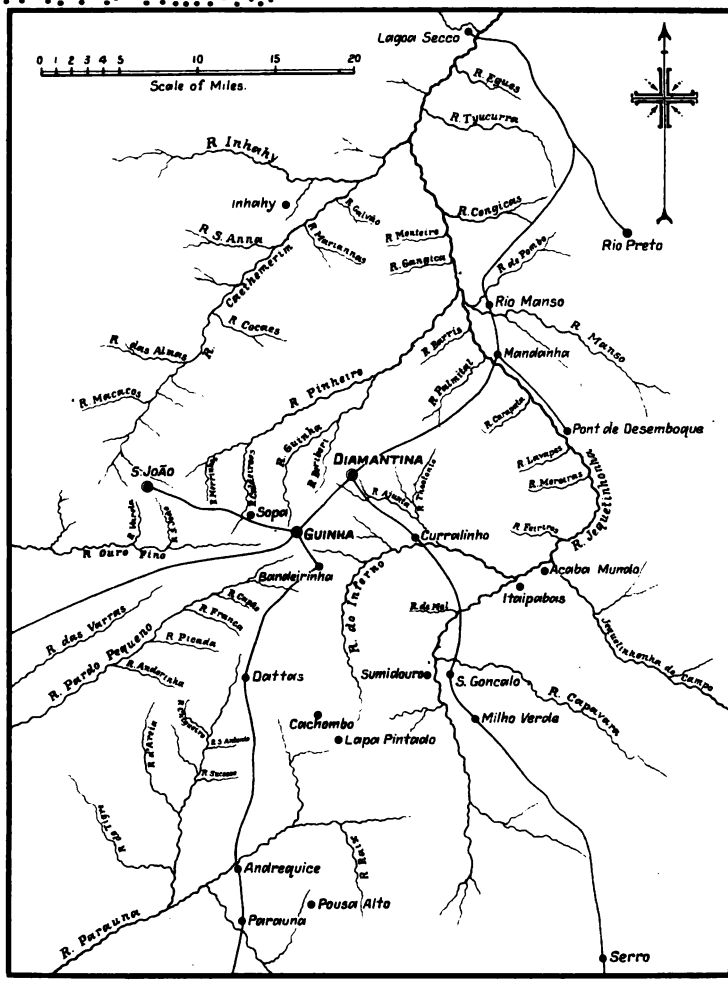
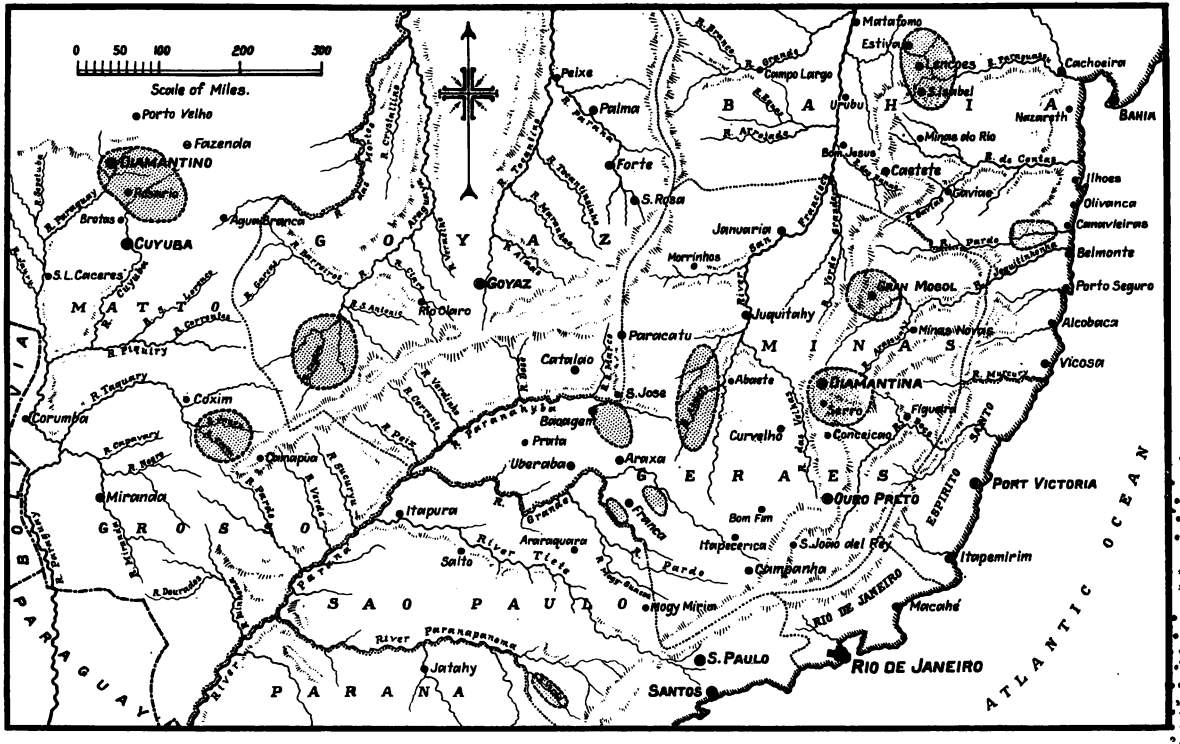


A. CAUE.
B. ESMERIL.
C. CONCEICAO.
D. ANDRADE.
E. MONLEVADE.
F. MORRO AGUDO.
G. COCAES.
H. BANANAL.
J. MORRO DA MINA.
K. ALEGRIA.
L. FABRICA NOVA.
M. GERMANO.
N. TIMBOPEBA.
O. CAPANEMA.
P. MUTUCA.
Q. GONGO SOCO.
R. GAYA.
S. AUGUAS CLARAS.
T. JANGADA.
U. CATTA BRANCA.
V. FABRICA.
W. CASA DE PEDRA.
X. SAO VICENTE.

PLATE 126.



THE DIAMANTINA DISTRICT.



THE DIAMOND FIELDS OF BRAZIL.

PLATE 127.

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NOV 28 '64 -5 PM	

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